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An Econometric Estimate of Baumol and Bowen Expenditures at Texas Public Universities Following Tuition Deregulation

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Dedication

To my son, Graham.

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An Econometric Analysis of Baumol and Bowen Expenditures at Texas Public Universities Following Tuition Deregulation

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Expenditures per FTE student have risen rapidly in real terms in public higher education in the United States for over three decades. Two theory-grounded hypotheses have been advanced to explain this growth. Baumol's (1966) "cost disease" argument is a macroeconomic perspective arguing that industries heavily reliant on skilled labor have limited ability to increase productivity but must increase their wage rate above their productivity gains to compete for this skilled labor in the labor market. Bowen's (1980) "revenue theory of costs" proposes a microeconomic explanation that universities raise all they can and spend all they raise. Bowen's thesis has been expanded into a behavioral theory by Martin (2011), who argues that the nexus of non-profit status, principal-agent confusion, and prestige seeking behavior are responsible for increased expenditures. Following Martin and Hill (2012), this study presents an econometric model that allocates expenditures to these two theoretical perspectives.

Statewide real average expenditures per FTE student at Texas public universities increased 9% from fiscal year 2003 to fiscal year 2011 following tuition deregulation. Analysis of yearly fixed effects suggests that this policy change led to an increase in real expenditures above pre-deregulation levels on the order of $1,400 per FTE student. The ratio of Bowen to Baumol expenses is highest at elite Research universities and is lowest at the least research intensive Master's universities.

Additional tuition revenue was associated with a decline of Bowen expenditures relative to Baumol expenditures at Research institutions of -5% while Emerging Research and Doctoral institution displayed substantial increases in Bowen expenditures relative to Baumol expenditures (6% and 4%). This finding suggests that lower-level research universities with aspirations to higher research intensity increase their proportion of Bowen expenditures in conditions of expanding revenue. Research universities used additional revenue to reduce an existing cross-institutional subsidy from graduate education to the rest of the institution.

Keywords: Texas, econometrics, higher education, tuition deregulation, cost of higher education

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Chapter 1: Introduction

Colleges and universities today spend larger sums in real terms on a per student basis than at any previous time in American history. This study is motivated by a simple question: Why has this spending increase occurred? To answer this question, I examine a natural experiment—the deregulation of tuition in Texas in 2003—when a set of public higher education institutions in a restricted spending environment were, overnight, turned into institutions able to price their education services at essentially any level the market would support. Observing changes in expenditures at these institutions provides insights into the decision-making that occurred when they were able to access an expanded source of income. Were these institutions constrained by economic forces beyond their control, with increased funds used to address systemic labor market issues? Or were they able to direct new expenditures toward focused areas of their institutions to achieve specific goals? Understanding the degree of agency institutions possess about expenditure decisions is critical to developing policy recommendations about the finance of public higher education.

BACKGROUND

The decreasing affordability of higher education has been an issue of scholarly interest for many years (Heller, 2001; Mumper, 2003) and has been identified as one of the key areas of recent scholarly work by Conner and Rabovsky (2011). Students have taken on an increasingly large share of the costs of operating public higher education. Between 2005 and 2010, for example, net per student tuition increased both in dollars (from $7,116 to $8,611) as well as in percentage of operating revenues (21% to 24%) at public research institutions (Kirshstein & Hurlburt, 2012). The increasing role student tuition plays in funding university operations has led to a large increase in the level of student debt over the last ten to fifteen years and there is evidence that this debt, in turn, constrains the choices of students after college (Rothstein & Rouse, 2010). As costs have risen, scholars have sought explanations for the phenomena. While some argue that decreased state appropriations play a key role in the burden taken on by students (Titus, 2009), total expenditures at higher education institutions have risen at a level above the rate of inflation in the overall economy.

Texas historically had tight Legislative control over institutional tuition and this control provided a check to growth in institutional expenditures. Following tuition deregulation in 2003, however, this tight control was removed. As a result, Texas provides a natural experiment to examine how expenditures change when constrained higher educational institutions are given the chance to increase real expenditures.

PROBLEM STATEMENT

National per student spending at public, four-year institutions has increased rapidly in the last three decades and dramatic increases in the real level of tuition paid by students provide most of the additional funds allowing this increase in spending. In Texas prior to tuition deregulation per student spending was essentially flat. Following tuition deregulation, real spending per student increased substantially.

PURPOSE

The research presented in this study uses the Texas case to demonstrate how universities allocate increases in expenditures—specifically whether those choices are constrained by macroeconomic factors in the general labor market (the Baumol hypothesis) or whether unresolved agency problems, the pursuit of institutional interests, and other microeconomic forces instead explain expenditure decisions (the Bowen hypothesis). This research develops an econometric model of institutional spending patterns both before and after tuition deregulation.

Research Questions

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

Significance

Both the Baumol and Bowen hypotheses contain elements of truth. What is most significant about this study is measuring, in a natural experiment, the relative importance of the two explanations of increased spending in higher education and how those expenditures change. This study also represents the first analysis that examines how these two explanations for expenditures are related to the level of research-intensity of the institution. While this research is not an evaluation of potential policy responses, understanding the forces that are increasing spending at public four-year universities is critical to addressing the challenges that are caused by these increases. To the extent, for example, that the Baumol hypothesis accounts for expenditures it is likely that the entire project of mass higher education as currently conceived is unsustainable and that fundamental changes in the delivery of education to post-secondary students must occur. On the other hand, to the extent that there are firm-level incentives pushing expenditures higher at universities, it is possible that regulation, control, and oversight of public higher education institutions could play an important role in shaping those incentives and in constraining the growth of these expenditures.

Key Elements of Existing Literature

The explanation for rising costs in higher education with the longest intellectual history is the Baumol hypothesis, often referred to as the "cost disease." The basic argument of the Baumol hypothesis is that technological improvements increase productivity and wages in the general economy, particularly among capital-intensive "progressive" industries. Labor-intensive "stagnant" industries are not able to achieve the same level of productivity gains as capital-intensive industries but must still pay market-level labor rates or lose employees to progressive sectors of the economy. Absent qualitative changes in technology that increase labor productivity in stagnant sectors the cost of providing these labor-intensive services will thus increase more rapidly than general inflation in the economy (Baumol & Bowen, 1966).[1]

An alternative explanation for the increase in higher education expenditures above the general rise of prices in the economy is provided by H. R. Bowen (1980). Bowen studied cross-sectional expenditure data for public and private institutions. He finds that there is a great divergence in per-student expenditures at universities and concludes that there is no external pressure enforcing standardized expenditure patterns on these institutions. In particular there is no external pressure to lower costs because universities are shielded from competition by geographic location and service differentiation. He concludes that what institutions categorized as needs "are arguments in favor of increased funding, not causes of increased costs" (H. R. Bowen, 1980, p. 16). He also points out that efforts to increase efficiency will not reduce "costs" but simply lead to a reallocation of spending. In his view, only reductions in revenue can lead to reduced expenditures.

[1] The initial work that developed this literature was written by William Baumol and William Bowen. The main competing theory to this approach, to be covered, was developed by the unrelated Howard Bowen.

Martin (2011) develops a behavioral framework to ground the Bowen hypothesis in economic theory. There are three main elements in his framework. First, the pursuit of prestige occurs because higher education is an “experience good”; consumers of the good determine its quality by “experiencing” it as opposed to testing various suppliers of the good through a search procedure (Nelson, 1970). Second, the constant activity of fund raising in higher education creates a “principal-agent problem” (Martin, 2011, p. 162). Third, the non-profit status of higher education institutions magnifies this principal-agent problem. In a for-profit enterprise, there is a clear line of control from the property holders (principals) to their agents (the employees of the firm) through fractional ownership. In a non-profit, however, there is no discrete ownership interest among the principals, whose property rights are held in common. Most important, however, is the fact that any financial residual produced by the non-profit firm is spent within the institution on staff and not distributed to shareholders as dividends.

METHOD

This study employs an established econometric methodology to construct regression models that link total per FTE student expenditures to a set of theoretical and control variables. Using the technique of partial derivatives, estimates of constant dollar yearly per student expenditures at Texas public universities are divided into amounts proportionally explained by the Baumol hypothesis, the Bowen hypothesis, and control instruments.

ASSUMPTIONS AND LIMITATIONS

The primary limitations imposed on this study involve the disaggregation of employment data available through the federal IPEDS system. While expenditure data in IPEDS may be separated by the function of the expenditure (e.g., student services), labor measurements are not similarly differentiated. As a result, the econometric analysis in this research models all expenditures at institutions, including those expenditures incurred by auxiliary activities such as residence halls and athletic faculties. Since auxiliary functions should (theoretically) be self-supporting, an ideal study would remove these expenditures and labor measurements from consideration of the rest of the enterprise. It is possible that future studies employing the basic methodology from this study (but using more detailed state-collected data) could provide more precise modeling of the determinants of expenditures in the academic functions of the university and measure cross-subsidization between academic and auxiliary activities.

SCOPE AND DELIMITATIONS

The expenditure data for this study was collected from Texas public, four-year institutions before and after tuition deregulation in 2003. The results of this model are only suggestive for public institutions in states where tuition either has been deregulated for some time or that function in an environment of regulated tuition. In addition, the results from this analysis have only limited application to understanding expenditures at private institutions. Finally, this study does not address how the quality of the educational product produced by increasing real expenditures might improve. For example, increases in spending on student services might lead to increases in persistence and graduation through increased student engagement (Tinto, 1987).

DEFINITIONS

- FTE Student: Full Time Equivalent Student. An institution has one FTE student for every 30 semester credit hours or 24 graduate semester credit hours.

- GASB: Government Accounting Standards Board. Promulgates accounting regulations for governmental entities such as public institutions of higher education.
- HC: Heteroscedastic-consistent estimate of standard errors.
- HAC: Heteroscedastic and autocorrelation consistent estimate of standard errors.
- IPEDS: Integrated Post-Secondary Education Data System. A federal clearinghouse of verified and validated comparable data collected at the institutional level.
- M-estimator: Robust regression technique that adjusts for heteroscedasticity.
- MM-estimator: Robust regression technique that adjusts for heteroscedasticity and the influence of outliers.
- NACUBO: National Association of College and University Business Officers. Professional organization that develops accounting categories for higher education expenditures.
- NCES: National Center for Education Statistics. Federal agency responsible for managing IPEDS.
- SCH: Semester Credit Hours. One SCH is awarded for attendance in one hour of classroom instruction over the course of a semester or for out-of-classroom work judged to be equivalent in content to one Carnegie Unit.
- THECB: Texas Higher Education Coordinating Board. The government agency charged with oversight of higher education in Texas.

ORGANIZATION OF STUDY

The substantive portion of this study contains four chapters. Chapter 2 reviews the existing literature on costs in higher education and presents a legislative history of tuition deregulation in Texas. Chapter 3 describes the econometric methodology used in this research. Chapter 4 presents a descriptive analysis of the dependent and independent variables at the statewide and THECB institution type level then synthesizes these descriptions into an overall picture of changes in these variables for the state public university sector.[2] Chapter 5 presents the results of the econometric model and answers the two research questions posed at the beginning of this chapter. Chapter 6 interprets these results and presents findings from specific instruments in the model germane to the literature described in Chapter 2. This final chapter ends with concluding thoughts about the implications of these findings for policy, the limitations of this research (and the consequences of these limitations), and ideas for additional research using the framework from this study.

[2] The Appendix to this dissertation lists the specific universities included in each THECB institution type.

Chapter 2: Literature Review

Chapter 2 reviews in detail the two major competing theoretical hypotheses that explain increasing costs in higher education. Following this comparison of the relevant theory the chapter then presents a legislative history of tuition deregulation in Texas. Before beginning this discussion, however, it is important to understand exactly what is being referred to as a "cost" in the literature.

THINKING CLEARLY ABOUT "COSTS"

One of the challenges in communicating about spending in higher education is that the simple word "cost" is used for at least three disparate purposes. By far the most common usage of "cost" involves research on the affordability of higher education. Dickeson (2006), for example, lists 27 potential explanations for how university mismanagement is increasing "costs" and decreasing access to higher education. Reynolds (1998) discusses how "statistics on gross tuition grossly exaggerate actual costs to most students and parents" (p. 105). This first use of the word might be better thought of as "student cost." Student cost properly defined involves out-of-pocket expenses for tuition and fees as well as living expenses for four to six years and the opportunity cost of working as opposed to studying. Winston (1998) points out that this conception of costs is particularly harmful to our understanding of the economic pressures on higher education because it invokes a "business intuition" where costs and profits together are equal to the price charged—as opposed to the actual circumstance in a non-profit firm where the net price paid plus a subsidy from other sources equals cost (p. 123). This incorrect understanding, he argues, leads to a failure to recognize that price *must* increase if the level of the subsidy decreases. In any event, "student costs"—and the discussion about the role of state support in determining tuition—is really not about "costs" *per se* but rather about how the burden of paying for higher education is distributed.

A second (and more fruitful) way to think about costs is how they are measured at the level of the institution. Adams, Hankins, and Schroeder (1978) describe two versions of this conception of cost as applied by the National Association of College and University Business Officers (NACUBO): "financial accounting," the ledger record of what was paid for various goods and services and "cost accounting," the effort at the level of the firm to apply these ledger records to its actions (p. 13). Together these are the "institutional cost" perspective, the transactional description of the decisions made by university officials on how collected revenue is expended. Assuming common accounting procedures, these institutional costs are theoretically comparable between public institutions operating under the same Governmental Accounting Standards Board (GASB) standards.

A significant difficulty in analyzing these expenditures, however, was created at the turn of the century by the imposition of a new accounting standard—GASB 34—that rendered many existing approaches to aggregating institutional financial data impossible. The new standard was put in place as of fiscal 2003 for all institutions with over $10 million in revenue (Lasher & Sullivan, 2004). This change in accounting convention makes it difficult to compare pre-2003 data to older historical trends and essentially impossible to compare public and private institutions, which operate under a different set of reporting standards. In addition to these definitional challenges, direct comparison of institutional cost categories at universities is difficult due to variation in institutional mission. For example, Dill and Soo (2004) describe the difficulty in distinguishing academic and research costs due to cross-subsidization of functions.

As a result, while the precise accounting of these institutional costs is of interest at individual institutions—they are, after all, the numerical tally of the political fight that is the development of the budget and thus the purest expression of the true value the institution places upon its functions (Wildavsky, 1961)—the precise allocation of expenditures by department and function is generally an institution-specific concern. Adams et al. (1978), however, point out a final category of cost—"economic accounting"—that ties the actions of the firm to both the larger economy and to the individual choices of economic actors. We might call this "actual cost"—the macro and microeconomic factors that dictate the production of education and research at the institution. While detailed institutional cost comparisons are fraught with difficulty, higher level aggregations of these choices into broad economic accounting categories is less contentious and can help us understand the systemic pressures faced by institutions. It is this third conception of "cost" that my research uses when referring to "expenditures."

THE BAUMOL HYPOTHESIS: EXPENDITURES RISE DUE TO DIFFERENTIAL PRODUCTIVITY GAINS IN THE ECONOMY

The explanation for university expenditures rising above the general price level with the longest intellectual history is the Baumol hypothesis, often referred to as the "cost disease." The basic argument of the Baumol hypothesis is that technological improvements increase productivity and wages in the general economy, particularly among capital-intensive "progressive" industries. Labor-intensive "stagnant" industries, are not able to gain the same level of productivity gains as capital-intensive industries but must pay market-level labor rates or lose employees to progressive sectors of the economy. Absent qualitative changes in technology that increase labor productivity in stagnant sectors, the expenditures required to provide these services will increase more rapidly than general inflation in the economy (Baumol & Bowen, 1966). In addition, stagnant industries tend to be ones in which the labor itself is essentially the end product (Baumol, 1967); the canonical example is the production of classical music. While Baumol's original work is based on the provision of artistic services, Baumol and Batey Blackman (1995) suggest that universities are subjected to the same dilemma confronting many labor-intensive industries.

In a later formulation of this approach, Baumol, Batey Blackman, and Wolff (1985) add a third type of industry—"asymptotically stagnant"—whose production function contains elements of stagnant and progressive elements. These asymptotic industries have the initial potential to see high rates of productivity growth. When additional capital is applied in these industries, however these investments have diminishing returns as the overall share of the cost of production shifts to the labor-intensive elements of their production function. An example is the shift in the relative cost of hardware and software in total computational costs (Baumol et al., 1985, p. 813).

Cowen (1996b) points out that all production requires some irreducible input of labor; without it, capital is simply un-utilized. As a result, if Baumol's logic is correct, as productivity increases there are no "progressive" industries in the long term. Cowen (1996a) expands on this arguing that, while unquantified, the aggregation of creativity over time yields substantial real productivity gains. For example, while chamber orchestras in 1780 could play only Mozart and Hadyn, the same type of performance group today has access to a much wider potential repertoire. Preston and Sparviero (2009) suggest a third refinement to address these concerns: "creative inputs" defined as "original ideas, concepts, actions, and inductive solutions to ill-defined problems" (p. 243). They suggest the act of creation is something that, fundamentally, cannot be replaced by mechanization. While their application for this refinement is in media production, the notion is clearly transferrable to employees in higher education institutions in their research role.

Besharov (2005) points out a significant weakness in the Baumol cost disease thesis: because there is no consumer welfare calculation, the theory provides no basis for arguing that (even accepting its logic) the provision of the good in question ought not to be allowed to decline. If the price of the good rises and, on the margins, some consumers shift their purchases to another good, that is simply the operation of market forces. Baumol (2012), without perhaps fully realizing it, admits this is the case as he ticks off a list of vanished former services such as home milk delivery and elevator operators.

The explicit link between higher education and future income streams makes this welfare calculation linkage even more powerful in higher education. To the extent that the existing delivery system cannot deliver knowledge and credentials to those who need it, perhaps another, less labor intensive, delivery system would be able to do so. For example, mass higher education could become a largely mechanistic, capital intensive activity devoted to workforce development while elite higher education becomes segmented off into a lifelong class indicator. Indeed, in a comment to Bowen's 1967 paper Bell (1968) points out that there has been no reduction in shaving activities due to the labor intensity of barbers (if anything shaving occurs more frequently) however the way the service is delivered has been radically changed through the development of the safety razor. Similarly, retailers no longer divide bulk purchases for customers due to advances in packaging.

On a policy level, if the Baumol hypothesis is correct, there is nothing to be "done" about these increases in expenditures. Sectors such as education and health care will inevitably encompass a higher share of GDP. This will not matter in the larger macroeconomic picture because productivity growth in other sectors will create wealth that can be used to purchase these goods. The challenges, Baumol argues in a retrospective piece, are to manage secondary effects (such as the differential consequences for the poor) and to deal with a larger share of the economy being managed by the government (Baumol, 1996).

Basing its explanation for increases in expenditures in broad changes in the overall economy, the Baumol hypothesis is fundamentally a *macroeconomic* explanation. Indeed, Archibald and Feldman (2006) point out that the Baumol hypothesis represents another version of work in international economics by Balassa (1964) and Samuelson (1964). This research demonstrates that the wealth of rich countries enables inhabitants of those countries to enjoy a higher standard of living due to the consumption of internationally tradable goods (e.g., automobiles) while goods produced with local labor (e.g., haircuts) are priced according to the local price level (and thus are more expensive in developed countries). Archibald and Feldman (2007) compare higher education costs to 69 other product categories and find that:

> From 1930 to 2000 the average price of durable goods rose by a factor of 4.12, the average price of nondurable goods rose 8.24 times, and the average price of services rose 11.11 times…. [A]fter 1980 the prices of services that rely on highly educated labor (lawyers, physicians, and dentists) rise much more rapidly than the prices of services that rely on less well educated labor (domestic servants and barbers). (p. 8)

Archibald and Feldman (2007) suggest that there is an additional macroeconomic factor at work—"capital-skill complementarity"—that boosts the demand for highly skilled labor when capital is added to the production function. Krusell, Ohanian, and Ríos-Rull (2000), for example, find that changes in capital-skill complementarity account for most of the post-war wage premium. They point out, however, that they are not intending to deny the agency of higher education leaders, merely that: "[o]ur analysis suggests that higher education decision makers are faced with choices that result in either rising costs or declining quality" (Archibald & Feldman, 2007, p. 21).

THE BOWEN HYPOTHESIS: EXPENDITURES CONSTRAINED ONLY BY REVENUES

An alternative explanation for increases in higher education expenditures above the general rise of prices in the economy is provided by H. R. Bowen (1980). Bowen studied cross-sectional expenditure data from public and private institutions for a variety of institutions with different missions for the 1974-75 academic year (a range of institutions, incidentally, that many later writers ignore in focusing on research universities). He finds a great divergence in per-student expenditures at these universities, even between institutions with similar missions. Bowen argues this divergence occurs because there is no external pressure enforcing standardized expenditures on these institutions and he locates the lack of external pressure in low levels of competition due to geographic location and service differentiation. Bowen concludes that what institutions categorize as needs "are arguments in favor of increased funding, not causes of increased costs" (H. R. Bowen, 1980, p. 16). He also points out that efforts to increase efficiency will not reduce "costs" but simply lead to a reallocation of spending. In his view only reductions in revenue can lead to reduced expenditures.

Accordingly he formulated what I will call for the purposed of this paper the "Bowen hypothesis" (also known as the "revenue theory of costs"). This hypothesis places the blame for increases in expenditure not on factors in the macroeconomy (as the Baumol hypothesis asserts), but rather onto decisions made at the level of the institution and thus grounded in *microeconomic* factors. This approach supports Bowen's earlier assertion (1970) that:

> [o]ne might go further and say that the biggest factor determining cost per student is the income of the institutions. The basic principle of college finance is very

> simple. Institutions raise as much money as they can get and spend it all. Cost per student is therefore determined primarily by the amount of money that can be raised. If more money is raised, costs will go up; if less is raised, costs will go down. (p. 81)

Bowen (1980) expanded this 1970 insight into five “laws” governing college budget decision-making:

- the dominant goals of institutions are educational excellence, prestige, and influence;
- there is virtually no limit to the amount of money an institution can spend for seemingly fruitful educational ends;
- each institution raises all the money it can;
- each institution spends all it raises; and
- the cumulative effect of the preceding four laws is towards ever increasing expenditure. (p. 19-20)

Because there is no “law” that provides a natural microeconomic restraint on expenditures, large increases in college expenditures are nothing more than the pursuit of educational excellence, prestige, and influence unrestrained by market discipline. The “duty” of setting limits falls on those who provide the money—legislators and families (H. R. Bowen, 1980, p. 18). One way of formalizing Bowen’s point is that, in contrast to economic entities with clearly defined production functions, there is no direct correlation between inputs and outputs at the firm level in institutions of higher education (H. R. Bowen, 1980).

It is tempting to see Bowen’s hypothesis as atheoretical because it appears to be specific to higher education. Archibald and Feldman (2007), for example, refer to a collection of such approaches as having “tunnel vision” and argue that they are merely a “descriptive analysis of what is going on in higher education and higher education alone”

(p. 5). Indeed, there have been researchers who have grafted onto Bowen's basic insight what amount to *ad hoc*, discipline-specific explanations. For example, Massy and Wilger (1992) propose a five-factor explanatory model including both Baumol and Bowen hypotheses while adding on regulatory overhead, the growth of an administrative "lattice" created by administrative entrepreneurs, and an academic "ratchet" privileging research over teaching as professors realize their careers rely on validation external to the university.

Getz and Siegfried (1991) argue that, from a social perspective, the problem of high expenditures is more important than the problem of high tuition and identify six broad points of view about why spending has increased. They identify Baumol as one of the six and add two market-based explanations (competitive market pressures for students and increased prices of inputs), pursuit of prestige among administrators and faculty (similar to Bowen), the quality of administration, and increased regulatory overhead. Through statistical modeling they conclude that market discipline plays a large role in restraining expenditures and "limits the ability of faculty or administrators to capture the institutions" (p. 390). They conclude that the impetus behind higher expenditures is higher demand and that institutions are "supplying a demonstrably higher quality service for a higher price" (p. 391). Given that both demand and quality are increasing, they argue, it is no surprise that expenditures increase as well.

Other researchers have, like Bowen, found similar variation in expenditures across institutions and attribute it to explanations also broadly grounded in microeconomics. For example, Brinkman (1981) argues that increasing expenditures are due to institutions operating "within a range of accepted norms" in the absence of a clear production function (Brinkman, 1990, p. 110). In that work, Brinkman proposes a four-dimension model to explain expenditures: size, scope of services, level of instruction, and discipline. His model explains 60% to 75% of cost variations (p. xi). Middaugh, Graham, and Shahid (2003) studied cost data by academic discipline in the Delaware Study and conclude that most of the variance in instructional cost at institutions is determined by disciplinary mix at the institution, with the institution's Carnegie classification being of secondary importance. Within-discipline variation across institutions is explained by volume of teaching activity, which exhibits economies of scale, while size of department, proportion of tenured faculty, and presence of graduate instruction all increase expenditures.

Martin (2011) argues that Bowen's argument is *not* atheoretical and presents a behavioral framework to support the Bowen hypothesis. There are three main elements in his behavioral framework. First, the pursuit of prestige occurs because higher education is an "experience good"; consumers of the good determine its quality by "experiencing" it as opposed to testing various suppliers of the good through a search procedure (Nelson, 1970). Visible displays of prestige—beautiful buildings, celebrated researchers, champion sports teams—signal to the consumer that the product they will purchase is of excellent quality. Second, the constant activity of fund raising in higher education creates a principal-agent problem (Martin, 2011, p. 162). A principal-agent problem can occur whenever one person hires another to perform a task and it reflects the differing incentives faced by each. The problem is generally addressed through the use of incentives to align the interests of the agent with the principal (Lane & Kivisto, 2008). This is a non-trivial task, particularly when output is poorly measured and when there are multiple goals for the principal from the relationship (Holmstrom & Milgrom, 1991), both circumstances that describe higher education. In particular, the persistent lack of information about the returns to instruction and the difficulty of identifying quality teaching exacerbates the principal-agent problem in the sector (Martin, 2012). For elite universities, large endowments also render the principal-agent problem more vexatious as they reduce the level of control principals may exert on agents (Martin, 2009).

It is in the third of the three elements that Martin makes his most significant contribution by describing how the non-profit status of higher education institutions magnifies the principal-agent problem. In a for-profit enterprise, there is a clear line of control from the property holder (principal) to the firm's agents. For example, a given fractional stock holding possessed by a principal represents that percentage of ownership in a firm. In a non-profit, however, there is no discrete ownership interest among its principals, whose property rights are held in common. Most important, however, is the fact that any financial residual produced by the non-profit is not distributed outside the firm (e.g., through dividends) but rather spent within the institution. In other words, non-profits spend these residual returns not on the principals who employ them but on the agents themselves. Indeed, as Martin points out, it is a very small step for a university to assert that its principals (students, parents, and external funders) and its agents (faculty and staff) are equal "primary stakeholders" in the activities of the institution. "This," Martin (2011) argues, "is how chronic agency abuse becomes institutionalized" (p. 84).

Agency abuse is always and everywhere linked to higher expenditures and is a general explanation for discrete observations of institutional behavior such as the "lattice and ratchet." This theoretical basis renders unnecessary explanations for increases in expenditures located in specific parts of the institution such as the "bureaucratic accretion" model posited by Gumport and Pusser (1995). Addressing this agency abuse, Martin (2012) argues, requires a change at the "center mass" of the problem: the administrators and boards with expenditure authority and on whose watch spending on overhead has exploded while overhead in the wider economy has been aggressively reduced (p. 25).

DEFINING PRESTIGE

Bowen and Martin both make clear that it is the search for prestige that drives the choices of higher educator officials in directing expenditures. One key aspect in determining institutional prestige is research—moving up the old Carnegie categorization from Research II to Research I, for example, has been used as an indicator for increasing prestige (O'Meara, 2007) and studies have attempted to examine how spending patterns at universities shift upon reaching the higher designation (Morphew & Baker, 2004). One less appreciated aspect of the linkage between research and prestige is that institutions that are heavily engaged in research should be analyzed as "multi-product firms," as described by Cohn, Rhine, and Santos (1989). (Simpler institutions focused on education can be analyzed in the more traditional fashion as a single-product enterprise.) As a result, an analysis that attempts to determine the systemic factors driving spending in higher education cannot examine only high-prestige or high-prestige-seeking research universities because single-product, instruction-only institutions may demonstrate significant variation in expenditure patterns.

There is also a potential link between tuition and research: tuition may be used to subsidize research not funded through external grants. An analysis of the spending patterns at 96 public Research Extensive industries between 1984 and 2007 suggests that one tuition dollar leads to a five cent increase in research expenditures (Leslie, Slaughter, Taylor, & Zhang, 2011). An econometric study by Heflin (2012) of all Carnegie-identified research institutions suggests that cross-subsidization occurs at public institutions at the level of 16 cents per tuition dollar and that subsidization increased between 1999 and 2008.

A second element in determining prestige is what Douglass and Keeling (2008) have called the "Pricing Equals Prestige Rule" (p. 4). In the absence of objective standards of measurable quality, consumers of higher education adopt a stance of "you get what you pay for" and use list price as an indication of quality. This phenomenon, observed in the private sector for many years, may explain some of the impetus for tuition deregulation as one of the stated goals of the policy change was to ensure that the "list price" of Texas' flagship universities was close to their public research peers in other states.

The final element in the prestige chase among universities are the "customers" themselves—students are both outputs *and* inputs. Better students create a virtuous circle. Universities are willing to grant a higher subsidy to these students to improve their output quality by controlling their input quality; "[t]he bottom line for any school is that it is donative wealth that buys this quality" (Winston, 1999, p. 30). For public institutions, lacking the large endowments of elite private institutions, even mild reductions in state appropriations can have the effect of significant reductions in what is effectively "donative wealth" Winston (1999, p. 37). In an intriguing paper, Eisenkopf (2007) presents a theoretical argument that tuition deregulation may lead to universities increasing tuition to deter unwanted students—an effect that would have an obvious, positive effect on prestige.

Institutions model themselves after each other, a behavior called "institutional isomorphism" by Reisman (1956). Each institution carefully monitors its immediate superiors, its peers, and its challengers and reacts as they react. Through this mechanism, the behavior of the top institutions is transmitted through the entire sector. Berdahl (1985) describes this as a tendency to copy prestige institutional behavior if unrestrained. Winston (2000) demonstrates in a stylized system that what institutions most closely monitor are "student subsidies"—the difference between the cost of the education and the price to the student—provided by their immediate competitors on the academic hierarchy.

He argues that there is a "positional arms race" where the best students choose the highest subsidy possible. Any degradation of the subsidy relative to the immediate peers of an institution has a high likelihood of degrading the quality of student attending the institution. Tuition deregulation enables institutions to increase this subsidy to favored students by extracting higher payments from less favored students.

COMPARISON OF THE HYPOTHESES

As with many cases of mutually conflicting theoretical possibilities, understanding university expenditures involves a mixture of competing explanations. Even one of the architects of the Baumol hypothesis, for example, acknowledges that the Bowen hypothesis must contain a kernel of truth—that competitive pressures are "an undeniable source of upwards pressure on costs" (W. G. Bowen, 2012, p. 8). Lingenfelter (2006) points out that, even adjusting with a specific price index for higher education (which presumably would neutralize the "cost disease" of the Baumol hypothesis), the "unit cost" of education is still increasing and this is explained by the competitive pressures embedded within the Bowen hypothesis.

One challenge to the Baumol hypothesis involves the large growth in expenditures on college administration, a point made by H. R. Bowen himself: "[A] strong case can be made that economies should be sought in the nonacademic part of institutional budgets rather than then academic part" (1980, p. 151). Recall that the fundamental insight of the Baumol hypothesis is that the "performer" in a labor-intensive task faces certain immutable barriers to productivity. Static productivity simply cannot address why institutions choose to hire an ever-growing number of additional, highly educated, talented people who are not providing instruction or research. Strein and McMahon (1979), for example, argue that administrative expenses in a university system are a function of discretionary revenue and found that “lower quality, local in scope, Ph.D. producing institutions show a strong, statistically significant administrative expense problem” (p. 21).

In an extensively cited article, Triplett and Bosworth (2003) examined multifactor productivity in Bureau of Labor Statistics two-digit service industries after 1995 and find that these industries display remarkable productivity growth during the period. They open the possibility that measured lower rates of productivity prior to 1995 could be related to technical limitations in the measurement of labor productivity for these sectors and conclude that perhaps “the cure for Baumol’s Disease was found years ago, only the statistics did not record it. Or perhaps the services industries were never sick, it was just…that the measuring thermometer was wrong” (p. 30).

Harter, Wade, and Watkins (2005) find that the largest determinant of the growth in real expenditures per student at public institutions is the growth in average real faculty salaries, a labor market where they compete directly for talent (and prestige) with private institutions. This finding is consistent with the Bowen hypothesis. In contrast, in an investigation of 67 industries from 1948 to 2001, Nordhaus (2008) finds that “[i]ndustries with relatively lower productivity growth show a percentage-point for percentage-point higher growth in relative prices,” exactly what the Baumol hypothesis (p. 10) would predict.

PUBLIC UNIVERSITIES AND EXTERNAL COST CONTROL

Breneman (2001) argues that the Bowen hypothesis applies with particular force—and may be measured empirically—at public universities (p. 16). Private universities either draw enough revenues to cover their actual cost of doing business or close; elite private sector institutions neither raise all they can nor spend all they raise.

Johnstone (2001) argues that it is only the public sector where university expenditures "are legitimately a public policy issue" (p. 29) and concludes that there is little evidence of "out-of-control costs" (p. 38). Jones (2001) points out that existing national research ignores the role in public institutional governance played by states, arguing that:

> [i]f Howard Bowen's revenue theory of cost has merit and if states wield policy influence to a degree commensurate with their share of institutional support, analysis of state funding and influence on tuition levels and affordability becomes the obvious starting point in the search for information that has utility for federal policymakers. (p. 54)

Martin (2012) contends that public institution budgets are in direct competition with other state services and this competition (along with the direct control of the institutions by public boards) enables public institutions to be better equipped to address the principal-agent conflict and restrain costs. Ehrenberg (2000) echoes this argument saying that there is:

> a fundamental difference between the governance of public and private institutions that makes it much easier for the public institutions to hold down their costs. Boards of trustees at public universities answer to the executive and legislative branches of state government. In contrast, in the short run boards of trustees at private universities answer directly only to themselves. (p. 24)

Leslie et al. (2011) describe significant differences between public and private higher education institutions; however, they find that private institution spending patterns match the Bowen hypothesis more closely than public institutions.

TUITION DEREGULATION IN TEXAS—A NATURAL EXPERIMENT

To date, no comprehensive history of the deregulation of tuition in Texas has been published. The existing research that has dealt with the policy change generally asserts that there was a *quid pro quo* of deregulation in exchange for lower state appropriations (Hernandez, 2009). While not entirely incorrect, the true story is more interesting and leads to valuable insights into how higher education leaders view the importance of increasing expenditures. This study now turns to a brief legislative history of tuition deregulation, using contemporary documentation, to stitch together a narrative of events leading to the policy change.

Public higher education institutions in the United States historically attempted to ensure broad access to higher education through strict state regulation of low tuition and fees (Hauptman, 2001). Prior to tuition deregulation this was the policy in Texas, where tuition was set by statute at a low per-credit hour amount and any proposed fee by a university required statutory authorization from the Legislature.

In 1995, the Legislature authorized a "Stair Step" plan to create regular, moderate, predicable increases in tuition and fees. These increases, however, were seen as insufficient to meet the (perceived) needs of universities, particularly universities such as the University of Texas at Austin (UT Austin), which had aspirations to increased national prominence. When the step increase plan ended, the University of Texas System (UT System) began to work towards a different strategy. In the summer of 2000, system officials first developed a new plan to meet the financial needs of the university—the removal of the state tuition cap. As part of preparing the system's budget request for the 77th Texas Legislature Charles Miller (Regent of the UT System) presented the first formal proposal for tuition deregulation in Texas, cast in terms of a general approach to deregulation across government "[t]here's just no reason we shouldn't have that in higher education too" (Badgley, 2000b).

The initial UT System proposal was to eliminate both minimum and maximum tuition regulations in statute and this drew criticism from some members of the Texas Legislature who feared it would price some students out of higher education. Regent Miller downplayed the concerns, arguing that deregulation was needed to decrease management inefficiency and that "[t]his does not imply any significant rise in tuition and fees" (Badgley, 2000a). He argued that there would be little effect on needy students since more than 50% of the increase would be put into financial aid.

By September 2000, the UT System had developed a formal proposal for the upcoming session and presented it to the House Committee on Higher Education. This proposal was described by UT Austin President Larry Faulkner as the "Flex Plan." Included in the plan was a second option to charge a flat tuition fee for undergraduate students taking between 12 and 18 hours. UT System Chancellor R. D. Burck insisted that the universities needed flexibility to react to inflation and other unforeseen costs and that "[t]his does not necessarily mean that fees would increase but it could" (Bello, 2000). Representative Henry Cuellar, vice-chair of the Committee proposed a new extension of the previous Stair Step increase to statutory tuition and raised the specter of the effect of deregulation on middle class students if tuition deregulation were to pass.

As the 77th Legislative Session opened, Chancellor Burck wrote an editorial laying out the case for deregulation more generally. He argued that universities were burdened with unnecessary rules and that these rules limited the ability of institutions to respond quickly to change. The proposed *tuition* deregulation, however, went unmentioned (Burck, 2001). In the end, the 77th Legislature took no action on tuition deregulation and instead renewed the Stair Step plan by adding $2 per semester credit hour for each of the next five years and $1 per semester credit hour for another five years beyond that, extending the approach through the 2011-2012 academic year (Stone, 2001).

This renewed Stair Step plan did not signal a stable bargain. On February 8, 2002, the UT Austin Board of Regents unilaterally authorized a large fee increase designed to repair aging buildings: $150 per semester initially, rising to $860 per semester in five years. At issue were two bills from the 77th Session: House Bill 658 (2001), which proposed construction bond money, and an amendment to Senate Bill 1759

(2001), which dealt with regulations concerning public securities. Officials at UT Austin argued that the changes made by the bills to a (seemingly) obsolete building fee statute gave them the authority to implement the new building fee even though no explicit statutory authority to impose this new fee was granted during the session. Commissioner of Higher Education Don Brown testified in February 2002 that if the UT Austin interpretation was correct the Legislature had “deregulated control over charges to students” to the universities and that he disagreed with the interpretation (Nissimov, 2002). In July 2002, Attorney General John Cornyn agreed with Commissioner Brown and the building fee was put on hold.

In addition to the backdoor tuition deregulation effort UT Austin pursued under the guise of the building use fee increase, in spring 2002 the UT System began preparing for a frontal assault intended to deregulate tuition formally. At a UT System meeting in Port Aransas in April the System regents and university presidents discussed the importance of a unified front in pursuing deregulation during the upcoming 78th Legislature (Mock, 2002). A September 2002 editorial is the first public hint at two new arguments for tuition deregulation—that allowing UT Austin and Texas A&M to set tuition would reflect the higher value of their degrees as well as give them additional funds to shore up their flagging flagship reputations (Lowery, 2002).

The 2002 state elections led to dramatic changes in Texas politics in the 78th Legislative Session as the Republicans took control of the House of Representatives for the first time since Reconstruction. The removal of Irma Rangel as the chair of the House Committee on Higher Education also removed a key institutional barrier to passage of tuition deregulation. Presumed Speaker of the House Tom Craddick said that the Legislature setting tuition at universities was “ridiculous” and that the various Boards of Regents should have that power (Jayson, 2002b). Mark Yudof, the incoming

Chancellor of the UT System, signaled a clear desire to push for sweeping tuition deregulation, citing the need to maintain top tier status along with encouraging students to graduate more quickly. Even with the political wind at his back, however, Yudof hinted at the possibility of some tuition being lowered “to encourage students to take classes in the afternoon” (Elliott, 2002b).

The final report of the Joint Interim Committee on Higher Education Funding recommended only very limited tuition deregulation (for summer classes and out-of-state students) with Senate Finance Committee Chair Steve Ogden saying “I’m opposed to the idea that our state institutions of higher education are really quasi-private and should charge what the traffic will bear.” Chancellor Yudof denied that there were specific plans to raise tuition and pointed out that states that deregulated tuition have tuition “about $1,000 a year” higher than UT Austin’s $4,000 (Elliott, 2002a). In addition, Yudof unveiled a proposal that students with income under $41,000 could send their children to any University of Texas campus free if tuition deregulation were passed (Jayson, 2002a).

Beyond the boost given to tuition deregulation by the switch of power in the House of Representatives, a second, and perhaps more important, process was playing out: the state was in its greatest budget crisis since the dark days of the savings and loan disaster of 1984-1985 and faced a massive deficit of $10 billion for the upcoming biennium. State agencies, including universities, were instructed to implement an immediate reduction of 7% from their previous biennial appropriation (Lim, 2003). The challenge of dealing with the budget shortfall was further compounded by Governor Rick Perry’s insistence that no new taxes be passed. A major part of Governor Perry’s plan to deal with the budget gap by cutting spending was allowing tuition deregulation to make up for the difference at universities (Herman, 2003). Chancellor Yudof estimated that tuition and fees could increase “as much as 27 percent over five years” if tuition deregulation were put into place (Jayson, 2003b).

These grim budget realities initially seemed to persuade legislators that tuition deregulation would need to be a part of any final appropriation level for higher education. Representative Fred Brown, member of the House Higher Education Committee, conceded that “deregulating tuition is likely to be the only answer to our budget constraints” while the Senate Education Committee Chair Florence Shapiro said that “[t]o put large amounts of money into higher education is not an option.” At the same time, the reality that the external pressure for tuition deregulation was being driven by UT Austin and the UT System became clear, with Howard Graves, Chancellor of the A&M System, and Lee Jackson, Chancellor of the North Texas System, both opposing the basic bargain of trading appropriations for autonomy (Kay & Jayson, 2003). President Faulkner then issued a threat to resurrect the building fee as an option if tuition deregulation was not passed (Jayson, 2003a).

In March, Senator Shapiro and Representative Geanie Morrison (Chair of the House Higher Education Committee) filed Senate Bill 1542 (2003) and House Bill 3015 (2003), after the chancellors of the other state university systems switched their position on tuition deregulation (Benton, 2003). By early April, however, the Senate bill no longer included the tuition deregulation provisions (since Senator Shapiro’s approach to link tuition increases to tuition increases in other states was found to be unworkable), replaced with a straight $12 per credit hour increase in statutory tuition. On the House side, a variation of the Yudof plan for low-income students was linked with tuition deregulation (Kay, 2003b). The Senate bill passed out of committee on April 22, while a final compromise on the House measure, a $23 per credit hour increase for each of two years followed by deregulation beginning with the 2005-06 school year and tuition set asides for students with financial need, enabled HB 3015 to be passed out of committee on April 23 (Drosjack, 2003). A week later, the House passed HB 3015 but limited tuition deregulation to a one-time change in 2005, with future increases requiring that universities fulfill conditions mandated by the Coordinating Board (Kay, 2003a).

There the measures stood for almost a month. As of May 21, when the Senate Education Committee voted out HB 3015, Senator Shapiro proclaimed "[t]here's no semblance of deregulation left." Plans were made for interim studies (the classic solution for a high-profile, failed Legislative initiative) and President Faulkner appeared to concede defeat, saying "We'll be able to manage the biennium with this bill" (Kay, 2003c).

Five days later, everything changed.

The drama of the Legislative session in Texas is the down-to-the-wire completion of the appropriation bill; at some level everything else is but a sideshow. And while the sideshow of the tuition deregulation bills was grinding away, Speaker Craddick had one final card to play—the Senate version of the appropriation bill contained $500 million more in funding for higher education than the House version. He gave Senators a stark choice: full, complete, and immediate tuition deregulation or accepting the lower House amount for higher education formula funding. Lieutenant Governor David Dewhurst agreed to the deal and on June 1 (a day before the end of the session) both chambers suspended their rules and passed complete tuition deregulation (Harmon & Kay, 2003).

Despite assurances to the contrary during the Legislative debate, universities responded to the new freedom by implementing large tuition increases, with average fall semester student tuition at four-year institutions increasing 72% over the next seven years, from $1,934 in 2003 to $3,323 in 2009 (Texas Higher Education Coordinating Board, 2010). The amount of legislative activity that university leadership engaged in to achieve this goal is reflected in the results of a survey of legislators following the 2003 session, which found that only 64% of legislators thought that Texas public university leadership complied with state laws against lobbying by government agencies (Wolf, 2004, p. 89). In his 2004 State of the School speech, Faulkner (2004) gave explanations of what the UT Austin did with the additional funds from tuition that suggest both Bowen and Baumol effects played a role—"faculty expansion" on the one hand and a three percent across the board raise on the other.

SUMMARY

There are two major lessons to take away from the legislative history of tuition deregulation in Texas. First, given the wide variety of explanations made by University of Texas officials on why tuition deregulation was necessary, there is no simple and clear stated justification to be tested. Rather the diversity of rationales provided by Chancellor Yudof and others suggest that the University and the System were willing to make virtually any case—even contradictory cases—if that argument led to a tactical advantage at a given point in time. In other words, the actual reason for the initiative cannot be determined from contemporary public pronouncements. All that can be ascertiained is that UT Austin and UT System leadership at the highest level felt increasing expenditures was of critical importance.

Second, while remaining catholic on the virtues of the approach chosen by the Legislature, for the purposes of social science research the complete switch from rigid regulation to complete deregulation provides an excellent "natural experiment" to test any number of propositions related to the finance of public higher education. Such an approach has been used in the past to examine changes in tuition policy. For example, Hübner (2012) examines the change in enrollment likelihood in German states introducing student charges following a constitutional court ruling that repealed the national ban on tuition and fees. Swail and Heller (2004) assess cross-national price sensitivity using natural experiments enabled by tuition policy changes in ten jurisdictions across five countries. Frenette (2005) measures the effect on enrollment of tuition deregulation in undergraduate professional programs in Canada. These studies reflect the first understanding of "student cost" described earlier (out-of-pocket expenses to access higher education) and measure how student behavior is affected by tuition policy changes. A similar study could be done for tuition deregulation in Texas. For example, Hernandez (2009) compares enrollment trends pre- and post-deregulation with particular emphasis on Hispanic students and institutions in the border regions.

These natural experiments, however, can also be used to investigate choices made by decision makers at universities about where to spend these substantial increases in funding from tuition revenues. In the Texas case, tuition deregulation did not simply lead to a distributional change, with students picking up a share of the cost previously covered by the state while the net budgets of institutions remained static. Rather, because it led to an overall increase in expenditures, it provides a test for both the Baumol and the Bowen theoretical hypotheses. To the extent that the Baumol hypothesis explains marginal behavior changes, we should expect to see the large increases in new revenue from tuition being used to compensate for wages across the institution that were low relative to prevailing market wages. To the extent that the Bowen hypothesis explains these changes, however, we should expect to see labor expenses at the institution increase in a concentrated fashion and in a manner designed to enhance the perceived values of educational excellence, prestige, and influence.

Chapter 3: Methods

Chapter 3 details the analytical approach used in this research. After reiterating the problem statement and research questions it briefly reviews the paradigm of econometrics and relates this research paradigm to the theoretical discussion from Chapter 2. Next, it describes the econometric design employed in this study, its source of data, the population examined, and defines the variables used in the analysis. It then details the econometric apparatus of the research along with the instruments included in that apparatus. Finally, it presents the functional form of the econometric model.

PROBLEM STATEMENT AND RESEARCH QUESTIONS

National per student spending at public, four-year institutions increased rapidly in the last three decades and dramatic increases in the real level of tuition paid by students provided much of the additional revenue that allowed this increase in spending. This study uses the Texas case to determine how universities allocated expenditures following tuition deregulation. Were these expenditures constrained by macroeconomic factors in the general labor market (the Baumol hypothesis) or do unresolved agency problems, the pursuit of institutional interests, and other microeconomic explanations instead explain expenditures (the Bowen hypothesis). This study answers two research questions:

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

THEORETICAL PARADIGM

This research is situated in the theoretical paradigm of econometrics. Greene (2010) quotes Ragnar Frisch (founding editor of the journal *Econometrica*) that the purpose of econometrics is the "unification of the theoretical-quantitative and the empirical-quantitative approach to economic problems and [is] penetrated by the constructive and rigorous thinking to that which has come to dominate the natural sciences" (p. 1). Econometrics is not simply "the application of mathematics to economics." Rather, Green states, econometrics "concerns itself with the application of mathematical statistics and the tools of statistical inference to the empirical measurement of relationships postulated by an underlying theory" (p. 2). It is worth teasing out the elements of this definition.

First, the econometric approach involves explicit linking of theory and measurement. It is not simply a recitation of economic statistics unmoored from explanation (e.g., a report of industrial statistics). Nor does the econometrician have the luxury of being able to define explanatory factors and construct a model linking them through stylized facts in *ceteris paribus* fashion (as a theoretical economist might). Linking theory and empiricism inevitably leads to real world relationships that are confounded by exogenous complexities. As a result, econometric models seek to replicate the *ceteris paribus* assumption of theoretical economics through the use of control variables and other statistical techniques that isolate the theoretical relationship of interest.

Second, variables included in econometric models should have a logical, causal, theoretical basis. In other words, developing an econometric model is not a data mining exercise in search of some largest possible explanatory statistic. "Surprising" variables that have putatively significant correlations but have not been previously identified as potentially causal should be treated with caution and approaches that create the possibility of spurious correlations (e.g., stepwise regression of dozens of potential independent variables) should be avoided.

Finally, the approach is unapologetically quantitative and empirical and as a result must use imperfect indicator variables to represent underlying theoretical factors. Econometric modelers are rarely able to create variables for measurement and thus cannot design indicators that replicate as closely as possible the factor under investigation. Rather, modelers are generally presented with a set of existing measures. The person constructing the model must apply subject matter expertise to select the indicator variables that are the best possible fit for the underlying factors. In other words, variables in econometric studies often represent a satisficing approach that measures the underlying factor with some (perhaps substantial) degree of imprecision. The toolbox of econometrics is designed to deal with this imprecision.

As Chapter 2 of the study explained, there are two major theoretical explanations for expenditures in higher education. The first of these, the Baumol hypothesis, contends that higher education is labor intensive and that, like other labor intensive industries, it is largely resistant to increasing output through productivity gains. Sectors in the general economy with production functions that can generate productivity gains will be able to distribute a portion of those productivity gains to labor while at the same time competing with labor-intensive sectors in the labor market. As a result, sectors that cannot capture productivity gains are subject to a “cost disease” that renders their goods and services more expensive to produce relative to the price level of the overall economy over time. The classic case of this cost disease is the production of artistic goods (e.g. symphonies).

In contrast, the Bowen hypothesis suggests that non-profit firms are subject to principal-agent problems. Lacking the discipline of a market and with principals (clients) only tenuously related to the decision making of the firm, these organizations are motivated to “raise all they can and spend all they raise” with additional revenue distributed to parts of the firm favored by those making budgeting choices. This constant erosion of self-interested agent behavior degrades productivity and, over time, increases costs for services produced by the firm. In higher education the accumulation of additional administration positions, reductions in faculty teaching load, and prestige seeking are potential results of principal-agent problems.

Martin and Hill (2012) describe an econometric methodology to test the relative scale of Baumol and Bowen cost effects. They examined Carnegie I and II public research institutions from 1987 until 2008 and found evidence for both Baumol and Bowen effects, with Bowen effects over twice as large as Baumol effects. Their model suggests that these Bowen effects arise due to an increase in administrative costs and are a result of weak shared governance at these institutions.

While exceptionally creative, Martin and Hill’s work has a number of limitations. First, it focuses on research universities and does not examine how Baumol and Bowen effects manifest themselves at other types of institutions (or even between *top* top-tier research institutions and institutions below these rarified heights). Second, their data is national (although they control for two regions) and as a result state-level policy changes such as tuition deregulation in Texas are both unlikely to be visible and degrade the predictive power of their model. Third, their data set uses expenditure records from as far back as 1989. Unfortunately, these early records were compiled using a different accounting standard than the current GASB 34 financial reporting framework and the fit between measurement categories in the two systems is imperfect at best. The remainder of this chapter describes the Martin and Hill approach in more detail and how I adapted their model to answer the two research questions posed at the beginning of this chapter.

PROCEDURE

This study presents an econometric model that links expenditures incurred at higher education institutions with variables designed to measure the relative effects of the competing Baumol and Bowen hypotheses. Institutional mission is presumed to have an effect on spending decisions and as a result the model controls for institutional type (and this control allows the model to answer the second of the research questions). Because the analysis uses time series data, the model controls for changes that occurred due to shifts in the overall environment by fiscal year and this allows for the investigation of the effects of tuition deregulation in Texas.

DESIGN

This study presents five sets of regression results: Ordinary Least Squares (OLS) and four extensions of this approach often labeled as "robust regression." These extensions are designed to address data structures that do not conform to the strict assumptions of OLS. The five regressions link total expenditures to theoretical and control variables from the literature of higher education economics, as specified in the Martin and Hill methodology. These robust regression techniques are described below.

SOURCE OF DATA

All financial and staffing data for this project are taken from the public Integrated Postsecondary Educational Data System (IPEDS) operated by the National Center for Educational Statistics (NCES). All data was recorded under GASB 34 accounting standards. The dataset is in the form of a balanced panel.

SUBJECTS/POPULATION

The initial selection criteria I used in querying the IPEDS database was all Texas public institutions offering four-year bachelor degrees from fiscal years 2003 through

2011 (nine years). Following this initial selection, three community colleges offering Bachelor of Applied Technology degrees were eliminated from the study population as were Health-Related Institutions that perform limited undergraduate education. This selection procedure left a total of 34 public, four-year institutions and a potential 306 degrees of freedom, more than sufficient for the number of variables contemplated for the regression model. One of these institutions (Sam Houston State University) had to be excluded as it did not report GASB 34 compliant cost data for fiscal year 2003 and including the institution would have required using methods for unbalanced panel data. A second institution (the University of Texas at Brownsville) was excluded due to its unique financial arrangement with the local community college district. As a result, 32 institutions, with 288 degrees of freedom, represent the study population.

VARIABLES

The study replicates, as closely as possible, the definitions Martin and Hill (2012) use to construct variables. I report variations from their approach (either due to different circumstances in Texas or ambiguities in their reported methodology) below. All variable names use Martin and Hill's naming convention.

Dependent Variable.

Martin and Hill define three variables to measure expenditures—academic costs (instruction, research, and public service), overhead costs (academic support, student services, institutional support, auxiliaries, and independent operations), and total cost (*tc*) the summation of the first two. While they construct regression models for all three types of expenditures, their analysis is limited to the total cost variable. This is understandable—IPEDS only imperfectly separates staffing measurements by categories that can be divided into academic and non-academic expenditures. In this study all modeling was conducted on the total cost dependent variable only. This variable is reported on a per FTE student basis by dividing total institutional expenditures by the FTE student (*ftestu*) independent variable described below.

Martin and Hill use a "real" total cost variable in their model—that is, the nominal dollars reported in IPEDS are adjusted to 2008 dollars using the Consumer Price Index (CPI). It is unclear when the inflation adjustment is made in their approach. In this study I chose to model using nominal dollar value and to transform these results to 2011 dollars using the CPI calibrated for the Texas fiscal year when calculating the results of the model. (Note that Chapter 4 presents real dollar values for these independent variables for analytical purposes.)

Independent Variables—Enrollments.

The next set of variables Martin and Hill define measure students at the higher education institution. (The authors do not specify the exact IPEDS field for these variables; in this study all counts refer to fall enrollment or employment figures.) The following variables are included for each institution/year in this study:

- FTE students (*ftestu*);
- Full-time undergraduate students (*ftug*);
- Full-time graduate students (*ftgrad*); and
- Part-time students (*ptstu*).

Independent Variables—Salaries and Benefits.

The model uses two measures of compensation: staff salaries (*staffsal*) and employee benefits (*benstaff*). These variables are constructed by adding wages and benefits across all expenditure categories, respectively, and dividing by the total number of FTE staff at the institution (detailed below). One critical element of Martin and Hill's method determines how these salaries should be allocated between Baumol and Bowen effects. The fundamental argument of the Baumol hypothesis is that "productivity is constant and that salaries are driven by external market conditions" (p. 22). Assuming a competitive labor market, it follows that changes in salaries and benefits unrelated to changes in staffing patterns at a firm must be due to macroeconomic causes.

Martin and Hill conduct a "correlation analysis" using the *staffsal* and *benstaff* variables to determine the proportion of each that can be related to staffing variables. They find that 48% and 49% of the variation in salary and benefits, respectively, could be explained by these variations (p. 23). Accordingly, they assign the remainders (52% and 51%) to the Baumol hypothesis but point out that this may overestimate the proportion of compensation the Baumol hypothesis explains if the correlation is incompletely specified.

In this study, rather than use a simple correlation, I construct two OLS models to link salary and benefits to the staffing variables included in the dataset. I then use the adjusted R^2 for these models to determine the proportion of compensation expenses that can be explained by microeconomic staffing changes and assign this value to the Bowen hypothesis. The remainders for the compensation variables are then assumed to be explained by macroeconomic factors and are assigned to the Baumol hypothesis.

Independent Variables—Faculty Measurements.

The FTE student measure *ftestu* is used to construct four of the five faculty measurements describing the contract status of academic employees:

- Contract faculty per 100 FTE students (*cf*);
- Part-time faculty per 100 FTE students (*ptf*);
- FTE Faculty per 100 FTE students (*ftef*);
- Teaching assistants per 100 FTE students (*ta*); and

- Ratio of tenure-track faculty to non-academic professional employment (*ttad*) (taken from the count of FTE executive/managerial employees and professional employees described below).

Independent Variables—Staff Measurements.

The next set of variables Martin and Hill define categorize the non-instructional staff at the institution:

- FTE non-professional employees per 100 FTE students (*ftenpro*);
- FTE executive and professional employees per 100 FTE students (*fteadmin*);
- Average number of reporting employees per executive (*staffsize*);[3]
- Part-time administrators per 100 FTE students (*ptadmin*); and
- Part-time non-professional staff per 100 FTE students (*ptnpro*).

Independent Variables—Revenues.

A key prediction from the Bowen hypothesis is that higher revenues drive higher costs. To measure these expenditures, Martin and Hill construct the following variables:

- Operating revenue per FTE student (*rev*);
- All "other" operating revenue per FTE student, a subset of operating revenue (*other*); and
- Investment income per FTE student (*invest*).[4]

Independent Variables—Fixed Effects and Controls.

Martin and Hill accomplish control of institutional variation by restricting their study to Research I and Research II institutions as well as including additional nominal

[3] The text is unclear on this variable; I include both executive and professional non-instructional employees in the count.
[4] Martin and Hill also use hospital revenue per FTE student. As no Texas institutions in this study had hospitals during the timeframe of the study I have eliminated this variable.

variables for institutions based upon Research I status, three location codes (New England, Great Lakes, and far-west location), STEM focus, possessing a medical school, and possessing professional school(s). Rather that replicate their variables, inappropriate for a population of schools restricted to Texas and that includes lower-level institutions, this study uses the five Texas Higher Education Coordinating Board (THECB) institution type ratings (Research, Emerging Research, Doctoral, Comprehensive, and Master's) to distinguish the categories of public universities in Texas as fixed effect variables.[5]

In addition to the control for THECB institution type, each record contains a fixed effect variable for the time period of the observation (since there was clearly substantial policy variation by year due to the exogenous shock of tuition deregulation). Thus the two control variables for the study are control variables for the type of institution ($I_1 \ldots I_5$) and a fixed-effect variable for each time period ($T_{2003} \ldots T_{2011}$).

APPARATUS, INSTRUMENTS, PROTOCOLS

The econometric model used to relate total costs (*tc*) to explanatory and control variables is the apparatus used in this research. Within that overall apparatus, individual instruments measure relationships of interest by using the technique of "partial differentials" in which portions of the overall model are set to a value of zero. The remaining estimated value measures the overall effect of the non-zero variables. This study reports THECB institution type averages by calculating average values by type for each variable in the model. The regression parameter estimates are multiplied by these average values to create estimates of explained expenditures by instrument for each instrument. Finally, a CPI multiplier is used to convert the results to 2011 dollars.

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[5] Note that some of these ratings are essentially aspirational in nature (e.g., the University of Texas at El Paso and the University of Dallas are considered the same type of Emerging Research institution). In general, however, THECB institution types are objectively determined and track the research and graduate study intensity of Texas public universities.

The protocols for this approach are those established in the literature to ensure that the assumptions of OLS regression are met: that functional form is correctly specified, variances are constant, values of the dependent variable are independent, there is no autocorrelation of values (reduced independence over time) and the population is normally distributed (Bowerman & O'Connell, 1993, pp. 153-154). Correct functional form is established through the theory underlying the included variables and investigating potential non-linear relationships during the modeling process through transformations of dependent and independent variables. Independence is checked though investigation of multicollinearity: in this study through the use of Variance Inflation Factor, a variable clustering procedure to identify underlying factors in the data matrix, and a reduced variable version of the model constructed using the least absolute shrinkage and selection operator (LASSO) (Tibshirani, 1996).

Robust Regression Techniques.

Regression equations solved using OLS can be shown under the Gauss-Markov Theorem to be BLUE—Best Linear Unbiased Estimator (where "best" means lowest variance of the estimate). This study presents an OLS model generated using the PROC GLMSELECT command in SAS. Unfortunately, the assumptions required for OLS estimates to be BLUE are rigorous and under real-world conditions are rarely met, particularly for balanced panel data structures (Petersen, 2009). OLS parameter estimates are sensitive to outliers with high leverage and even a small number of these outliers can skew parameter estimates. In addition to biased parameter estimates that can be generated through influential outliers, OLS models can report false, low standard errors when the data structure displays non-constant variance (Petersen, 2009, p. 443) a condition known as heteroscedasticity. Finally, time series data is often observed to violate the independence assumptions of OLS because of autocorrelation—sequential and predictable variation in the observations (e.g., seasonality trends). (Note that correcting sources of heteroscedasticity also corrects for the final OLS requirement that residual error terms be normally distributed.)

Deviations from the Gauss-Markov assumption of homoscedasticity can be partly addressed through changes to the residual structure that modify the standard errors reported by the procedure (generally upwards) without changing the mean value parameter estimates OLS provides. These adjusted standard errors are estimated using either heteroscedasticity consistent (HC) or heteroscedasticity and autocorrelation consistent (HAC) estimators.

In the OLS equation, variance is equal to the sum of the squared residual terms. The insight behind HC adjusted errors is that squared residual terms carry with them a constant weight of one. White (1980) developed both the first general test for determining the presence of heteroscedasticity as well as the first HC procedure which could correct for it in an OLS solution (prior to his work the structure of the heteroscedasticity had to be known before it could be corrected). When a data structure is homoscedastic, the covariance matrix it generates is diagonal. White's insight was that heteroscedasticity is a variation from this diagonal matrix structure and that it can be corrected for by assigning differential weights to the residuals exhibiting heteroscedasticity that would pull them back to the diagonal vector. Since White, a number of HC estimators have been developed to deal with inefficiency in small sample sizes in the White estimator. For a review of these see Zeileis (2004).

The HAC estimator is an extension of the HC estimator and was developed by Newey and West (1987) to correct for autocorrelation in time series datasets. Their discovery was that a computationally simple secondary weight based on time distance from an existing observation could be used to reduce the proportion of information falsely assigned by OLS to serially-correlated observations. They accomplished this by defining a linear reduction as shown in Equation 1:

$$w(j,m) = 1 - [\frac{j}{m+1}] \tag{1}$$

Where:
m = maximum lag distance (specified by the modeler); and
j = lag distance of the observation.

The Newey West estimator requires that the modeler specify a lag period during which autocorrelation might occur. Specifying a lag value of 1 corrects for first order autocorrelation (AR1), when the observation of the immediately preceding period is correlated with the current observation. Higher lag values are used to correct for trends that vary by time period. Common lag values used are 4, 8, and 12 to adjust for the quarterly reporting, quarterly reporting over a two-year time period, and seasonal variation. Since Texas public universities are funded by the Legislature on a two year budget cycle and this generally results in increased appropriation amounts in biennial fiscal years I chose a lag period of 4 for the Newey West estimator. I use PROC MODEL to solve for both the HC and HAC adjustments to standard errors and specify the Generalized Method of Moments method of estimation and the Bartlett kernel.

Identification of influential outliers can be accomplished through a variety of measurements of dispersion and leverage. A naïve approach to dealing with outliers is to remove them from the dataset—and in cases of measurement error where there is no underlying information in the observation this can be the appropriate approach. When outlier observations contain information, however, eliminating this information by dropping these outliers can seriously skew parameter estimates and standard errors generated using the truncated dataset. So, how to A) include at least some of the information from the observation while B) not allowing the overall model to be impacted severely by outliers? The solution is provided by robust regression. (As an aside, it should also be clear that these solutions do eliminate some information and thus are not BLUE in conditions of perfect homoscedasticity and without influential outliers.)

Robust regression techniques vary from OLS and OLS-derived approaches such as HC and HAC because they change the transformation of the residuals used to generate the regression equation from a sum of squared values to a different function that modifies the weights given to residuals prior to the solution of the regression equation. This results not only in different standard errors (as HC/HAC) but also in different parameter estimates. The class of robust regressions designed to address heteroscedasticity are called "M-estimators." In this study I use the M-estimation technique described by Huber (1964) and implemented in SAS in PROC ROBUSTREG. Huber's approach divides residuals into two categories—those whose dispersion is above and below some threshold *d* (in this study I use the SAS default value of *d*=2.5). For residuals with absolute values under this threshold, the squared value of the residual used to solve the regression equation in OLS is divided in half. Residuals above this threshold, on the other hand, have their values truncated to the threshold value of *d* divided by 2. The practical effect of this transformation is that the influence of residuals with higher dispersion is limited at the cost of removing some of the information from residuals with lower dispersion.

While M-estimators do an excellent job at controlling for heteroscedasticity, they are ineffective in controlling for data structures contaminated by influential outliers because they cannot distinguish between "good" leverage points with information from “bad” leverage points that represent contaminated data (Chen, 2002).[6] A separate category of residual transformations attempts to distinguish these two cases—these are known as “MM-estimators.” These transformations replace the linear weights used by M-estimators with weights defined by a curve of Gaussian form.

SAS provides two options for MM-estimators within the PROC ROBUSTREG command (TUKEY and YOHAI) that differ in the level of asymptotic efficiency of the Gaussian curve use for adjustment (and as a result the amount of information they attempt to conserve). These estimators also assess “breakdown value,” the smallest fraction of contaminated observations that will cause the estimator to fail. In this study I use the YOHAI estimator (Yohai, 1987) with SAS defaults (which are set for a breakdown value of 0.25 and asymptotic efficiency of 72.7%). Again, the tradeoff inherent in this estimator should make it clear that it is not BLUE in cases of homoscedasticity. I report five regression results: OLS, White (HC), Newey West (HAC), Huber (M), and Yohai (MM).

Control Instruments.

Martin and Hill group the independent variables of their model into seven instruments (p. 20-21). Two of these instruments function as controls. The “Scale Changes” instrument includes three of the four enrollment variables listed above (*ftestu*, *ftgrad*, and *ptstu*) as well as teaching assistants (*ta*) to track graduate study intensity.

Their second control instrument is “Cost Savings” and is measured by changes in the ratios of contract faculty (*cf*), part-time faculty (*ptf*), non-professional employees (*ftenpro*), and part-time non-professional employees (*ptnpro*) per FTE student. The first two variables measure cost savings generated from shifting to non-full-time faculty. The

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[6] As implemented in PROC ROBUSTREG the M-estimator procedure does alert the researcher to their presence and will recommend the use of an MM-estimator.

second two variables in this instrument similarly measure the savings from moving to part-time, non-professional staff.

Taken together, these two instruments tell an important part of the story about expenditures at universities. The Scale Change instrument estimates financial costs (or savings) from enrollment changes. The Cost Savings instrument estimates what is essentially a form of revenue—funds that may be reallocated to preferred spending within the institution. Finding significant reallocation of funds would provide support for Bowen's hypothesis (since these savings could have been passed to students or returned to the state rather than distributed within the firm) and demonstrates the existence of winners and losers in a budget struggle at the level of the firm.

Instruments in the Baumol Decomposition.

Martin and Hill measure expenditures allocated to the Baumol hypothesis using two instruments—"Baumol Benefits" and "Baumol Salaries." These are simply the variables of staff benefits (*benstaff*) and staff salaries (*staffsal*) proportionally allocated to the Baumol explanation as described earlier.

Instruments in the Bowen Decomposition.

The first instrument in the decomposed Bowen cost estimate is the remainder of Baumol Benefits and Baumol Salary instruments—"Bowen Benefits" and "Bowen Salaries." (Note that, since the parameter estimates for benefits and salaries do not vary for Bowen and Baumol estimates, this instrument is reported as "Compensation" in Chapter 5.)

The Bowen hypothesis also includes three other potential explanations for changes in expenditures, measured using three different instruments. One of the key arguments of the Bowen hypothesis is that the agency problem in non-profit firms leads to decreasing productivity over time. Accordingly, Martin and Hill have an instrument to measure expenditure changes due to declines in productivity: “Bowen Productivity.” This instrument includes the variables measuring FTE faculty (*ftef*), FTE executive and professional employees (*fteadmin*), and part-time administrators (*ptadmin*) per 100 FTE students as well as the average number of employees per executive (*staffsize*).

The second instrument Martin and Hill describe measures the two significant potential sources of agency power in a higher education institution—the faculty and the professional administration (non-professional staff having little control over spending allocations). Martin and Hill call this the Governance instrument and describe three potential types of power structure as the “tenured faculty” explanation (where faculty members prevent cost-conscious administrators from making cuts), the “spendthrift administrator” explanation (where funds are spent on non-academic enterprises), and the “shared governance” explanation (where there is a power balance between faculty and administration that keeps agency problems in check). It is in this last category that Martin and Hill assert institutional cost containment can be found.

To measure the Governance effect, Martin and Hill use the ratio of tenure/tenure-track faculty to full-time administrators (*ttad*) as a measure of the balancing strength between the two groups. Martin and Hill include a squared term for this ratio and argue that a convex curve with a global minimum implies an optimal ration of faculty to administrators in shared governance, when the power of each balances the agency problems of both.

The final instrument Martin and Hill (2012) use is a measurement of costs related to revenues that addresses the Bowen observation about institutions “raising all they can and spending all they raise.” This instrument is constructed using total operating revenues less investment income (*rev*) as well as potential sources of revenue substitution from external donors and unspecified additional sources of revenue (*other*). The derivation of the donor variable is unclear from their monograph. In addition, because of the unique Texas funding structure of the Permanent University Fund (and to a lesser extent the Higher Education Assistance Fund), investment income could play a significant role in explaining public higher education expenditures in the state. For this reason I use the *interest* variable in lieu of donor income.

FUNCTIONAL FORM OF REGRESSION EQUATION

This study uses a regression equation with a dependent variable of total costs per FTE student. Independent variables for the model include the four instruments described above as well as fixed effects for data year (T_i) and institution type (I_i). Martin and Hill suggest a log transformation of the dependent variable (p. 14) to incorporate non-linear effects. Since total expenditures per student varied substantially less in the case of Texas institutions than in the longer period and national sample Martin and Hill used I investigated whether a linear version of their regression equation would yield acceptable results. Applying a log transformation did not improve the adjusted R^2 or *F*-value of the model so I did not transform the dependent variable. This choice also results in a more comprehensible functional form and parameter estimates that are easily interpretable.

The functional form of this model used in this research is as follows:

$$\mathrm{tc}_{it} = \beta_0 + \beta_{(1)} x_{it} \ldots \beta_{(n)} x_{it} + \mathrm{I}_i + \mathrm{T}_t + \mu \tag{2}$$

Where:
tc = Total cost per FTE student;
i = Institution type from 1 to i;
t = Time periods from 1 to t;
n = Model independent variables from 1 to n;
I_i = Fixed effect for each institution type i;
T_t = Fixed effect for each time period t;
β_n = Parameter estimate for variable n; and
μ = Estimate of error term.

As described earlier, PROC GLMSELECT, PROC MODEL, and PROC ROBUSTREG are used in this study to calculate five solutions to Equation 2. By aggregating the total measured value for each university in a given THECB institution type in each year, I calculated a weighted average of each variable for each year. For example, summing up all teaching assistants and all FTE students in Emerging Research institutions and then dividing the first by the second will provide a properly weighted value for the variable *ta* at this institution type. These weighted variables are then applied to the regression model to create estimates of explained expenditures. Decomposition of the general equation into two partial differential equations representing the Baumol and Bowen hypotheses is used to generate the overall estimate of Bowen and Baumol expenditures and for estimates of each of the instruments.

The partial differential equation for Baumol Costs as defined by Martin and Hill is:

$$\partial(\mathrm{tc})^{Baumol}_{Total} = \partial(\mathrm{tc})^{Baumol}_{Salary} + \partial(tc)^{Baumol}_{Benefits} \tag{3}$$

Similarly, Bowen costs are defined as:

$$\partial(\mathrm{tc})^{Bowen}_{Total} = \partial(\mathrm{tc})^{Bowen}_{Salary} + \partial(tc)^{Bowen}_{Benefits} + \partial(tc)^{Bowen}_{Productivity} + \partial(tc)^{Bowen}_{Revenue} + \partial(tc)^{Bowen}_{Governance} \tag{4}$$

The approach used in this study varies somewhat from the Martin and Hill methodology. They calculate a weighting factor for each institution based on *ftestu* in the first year of their data. This weighting term is then used to distribute the output of the model for each institution and addresses problems caused in their study by lack of a balanced panel dataset. In this study, in contrast, I am able to use calculated partial differential values to create a balanced time series estimated dataset for all fiscal years in the study resulting in a richer potential for descriptive statistics generated by the model.

Martin and Hill distribute the error term from their model through this same weighting approach as an in-sample forecast (p. 18). Because the THECB institution type predictions in this research are directly measured from aggregated sums of the independent variables, no weighting factor exists to distribute these error terms and they are not assigned to either of the hypothesis or the control variables or instruments.

INSTITUTIONAL REVIEW BOARD APPROVAL

I completed all required IRB training and I completed all required IRB forms in the web application hosted by the Office of Research Support. This research proposal was classified as “exempt” from IRB review as it uses institutional level aggregated data that may not be decomposed to the individual student level.

Chapter 4: Analysis of Changes in Model Variables over Time

Chapter 4 describes how the statewide average value for each of the variables used in the econometric model in this study changed over time and presents variations among the five THECB institution types of public universities. Following this variable-by-variable review, it synthesizes these descriptions into both an overall statewide picture of change and variations from this statewide picture by THECB institution type.

MEASUREMENT OF THE DEPENDENT VARIABLE

As described in Chapter 3, the dependent variable I use in this study is total cost (*tc*), measured on a per FTE student basis (*ftestu*). Between 2003 and 2011, total expenditures per FTE student grew from \$20,168 to \$21,960 in inflation-adjusted 2011 dollars—an increase of 9%.[7] This is presented in Figure 1.

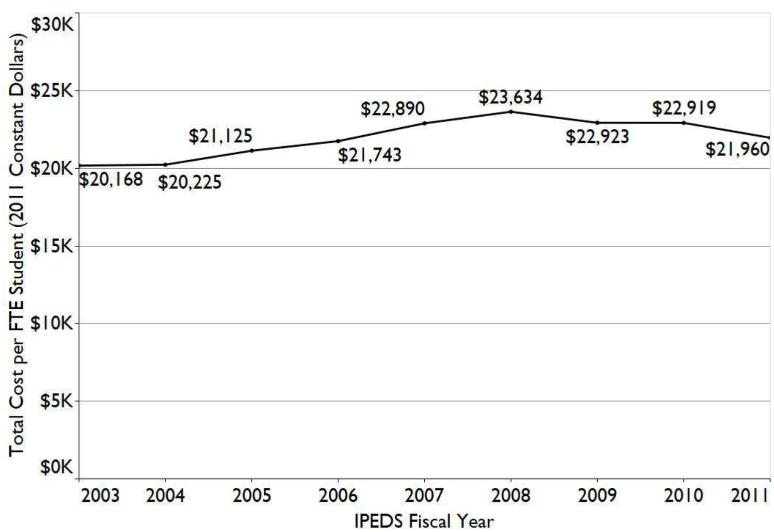

Figure 1. Average real total cost (*tc*) at Texas public universities.

[7] This chapter presents 2011 dollar values adjusted for inflation using the CPI index. The econometric model uses nominal dollars for each year and converts predicted dollar amounts into 2011 real dollars.

Increases in total cost vary by THECB institutional type. Figure 2 demonstrates these differences. The large difference in expenditures per student at Research institutions is particularly notable and supports the importance of a broad examination of all types of public universities. Institutions also display different patterns of change in per student expenditures. Research universities increased expenditures dramatically in real terms in the four years immediately following tuition deregulation, from $39,627 to $46,012 (14%), suggesting that the policy change led to a one-time adjustment upwards in expenditures. The other four THECB institution types displayed smaller increases in real expenditures, ranging from 5% at Emerging Research Universities to 12% at Master's universities. Tuition deregulation was thus associated with larger increases in expenditures at the university type with the highest level of research expenditures.

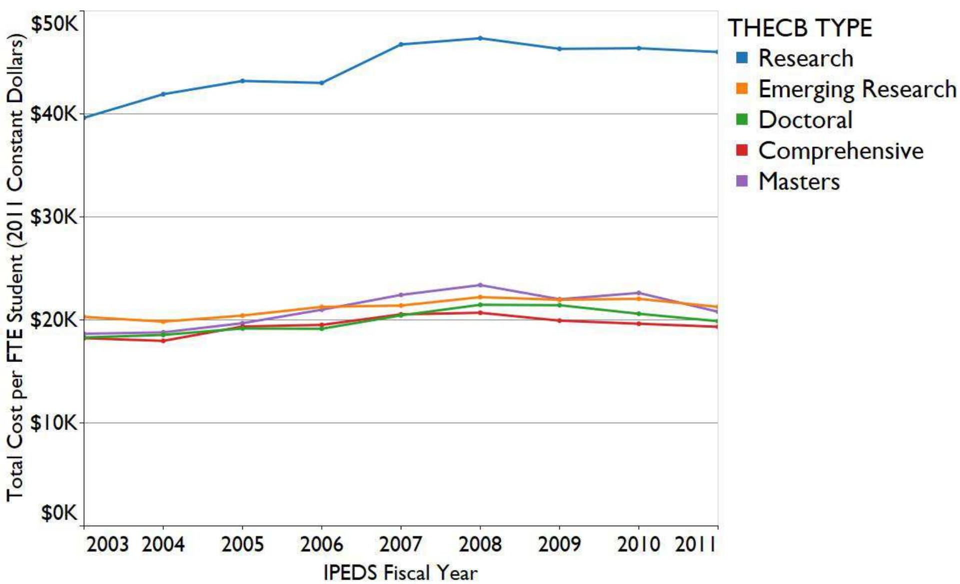

Figure 2. Average real total cost (*tc*) at Texas public universities by THECB institution type.

MEASUREMENT OF THE INDEPENDENT VARIABLES

This chapter now turns to describing the independent variables included in the econometric model. I group these variables into four categories: enrollments, salaries and benefits, faculty measurements, and revenues.

Measurement of the Independent Variables—Enrollments.

The first set of independent variables Martin and Hill define in their econometric model measure the number and type of students at an institution: FTE students (*ftestu*), full-time graduate students (*ftgrad*), and part-time students (*ptstu*). This section describes the statewide average and average by THECB institution type for each in turn.

The first of these variables is FTE students (*ftestu*). Figure 3 presents the statewide institutional average for this variable, which increases from 11,810 to 14,154 FTE students (20%).

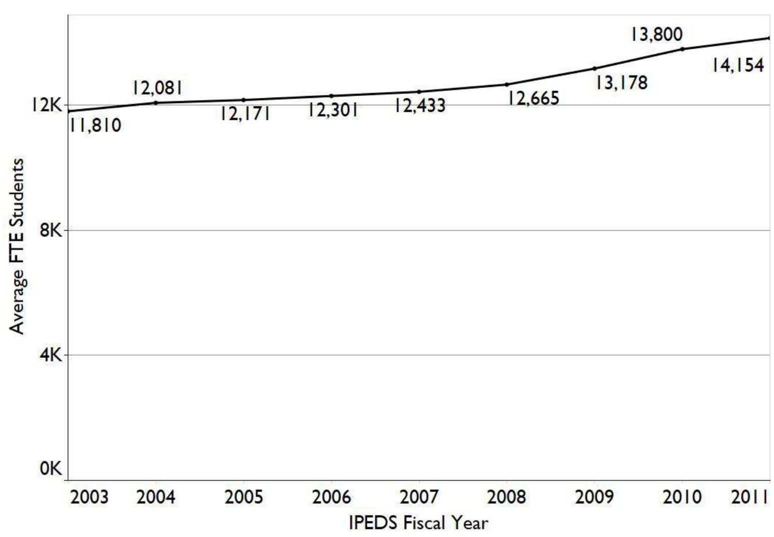

Figure 3. Average FTE student enrollment (*ftestu*) at Texas public universities.

Figure 4 demonstrates the difference in scale between THECB university types. The two Research universities (UT Austin and Texas A&M) are much larger than the rest of the sector. Of note is the increase in enrollment that occurred at all university categories but Research universities. Emerging Research institutions increased substantially both in raw numbers and in percentage terms, from an average of 20,714 FTE students in fiscal year 2003 to 25,821 FTE students in fiscal year 2011 (25%). Comprehensive universities increased 22%, Doctoral universities increased 28%, and Master's universities increased 19%. In contrast, to these large rates of enrollment growth, Research universities increased only 6%.

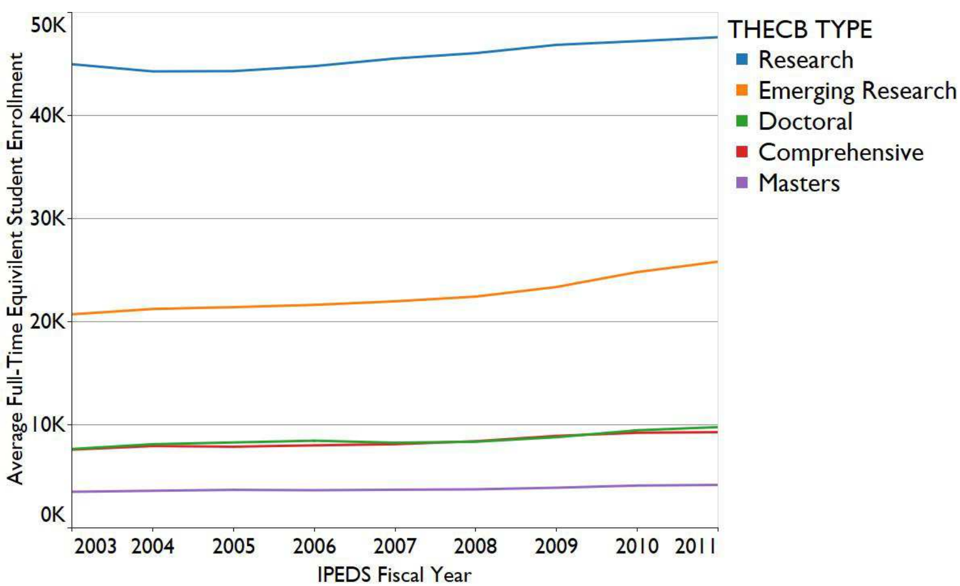

Figure 4. Average FTE student enrollment (*ftestu*) at Texas public universities by THECB institution type.

Figure 5 demonstrates that the average number of full-time graduate students (*ftgrad*) in Texas remained relatively constant from fiscal year 2003 through fiscal year 2008, increasing from 1,481 to 1,550 (5%). Beginning in fiscal year 2009, however, average graduate enrollment began to increase markedly, growing to 1,852 in fiscal year 2011 (a 20% increase in only three years).

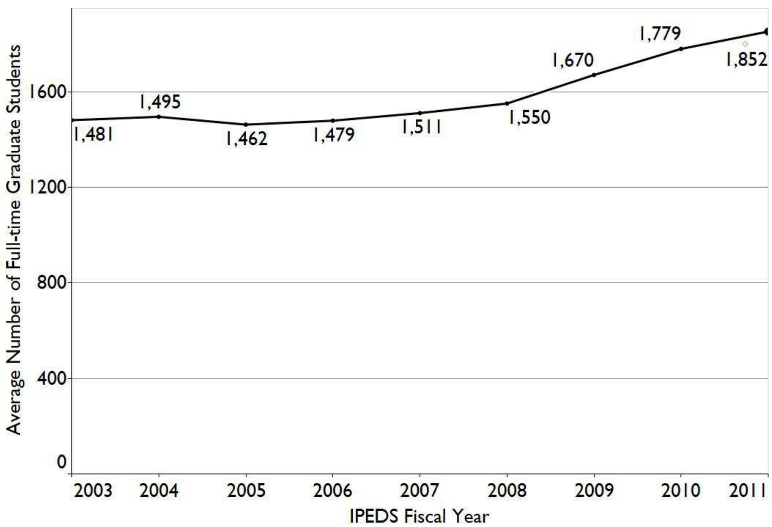

Figure 5. Average full-time graduate student enrollment (*ftgrad*) at Texas public universities.

Figure 6 establishes that the increase in average full-time graduate school enrollment was concentrated at Emerging Research universities, where average enrollment grew from 2,588 to 3,285 (27%). Doctoral universities also displayed a sharp increase in the final year of the study period, from 923 to 1,079 (17%). In contrast, average full-time graduate student enrollment at Research universities only increased from 9,250 to 9,581 during the study period (4%).

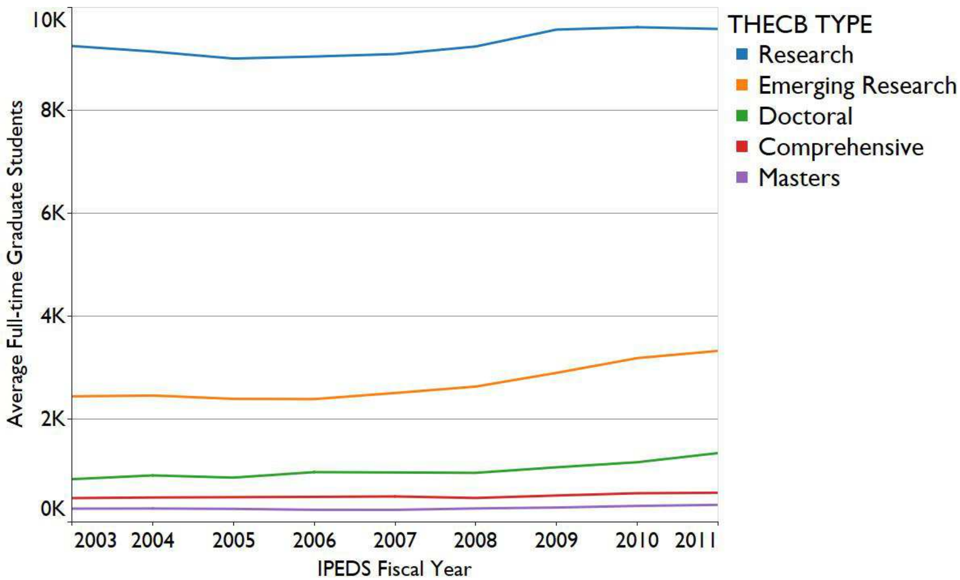

Figure 6. Average full-time graduate student enrollment (*ftgrad*) at Texas public universities by THECB institution type.

The next enrollment variable included by Martin and Hill is part-time student enrollment (*ptstu*), presented in Figure 7. As with full-time graduate student enrollment, part-time student enrollment was relatively flat through 2007 (4%). From 2007 through 2011, on the other hand, part-time student enrollment increased 16%. For the entire study period, average part-time enrollment increased 20%.

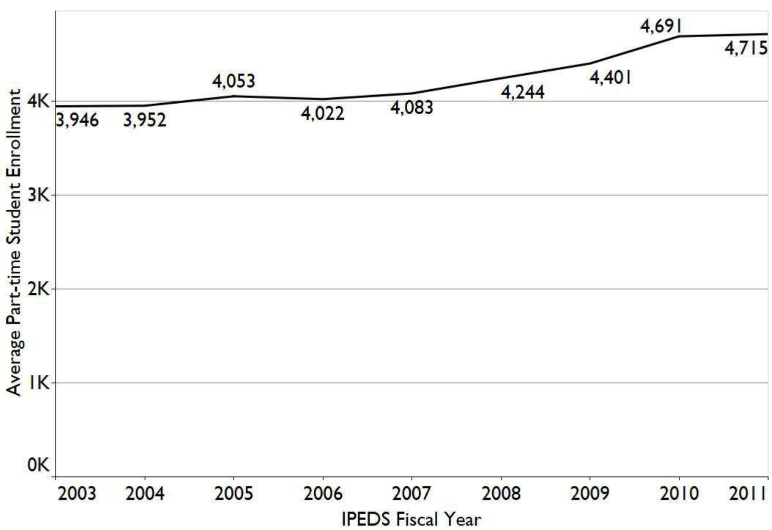

Figure 7. Average part-time student enrollment (*ptstu*) at Texas public universities.

Figure 8 demonstrates that growth in part-time student enrollment was largest at Doctoral and Comprehensive universities, which displayed increases of 35% and 30% respectively. Part-time enrollment increased at Emerging Research institutions by 17% and at Master's institutions by 15% while Research universities declined by -3%.

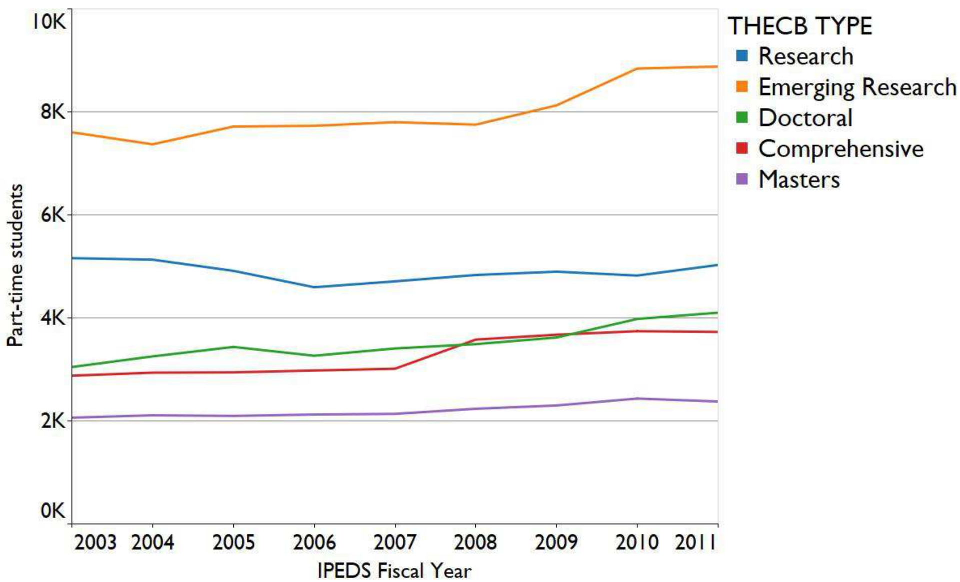

Figure 8. Average part-time student enrollment (*ptstu*) at Texas public universities by THECB institution type.

Along with an expansion of graduate enrollment in absolute terms, the ratio of teaching assistants per FTE student (*ta*) also increased during the study period, as detailed in Figure 9. From 2003 through 2011, this ratio increased 35%. This represents a substantial increase in support for graduate education statewide.

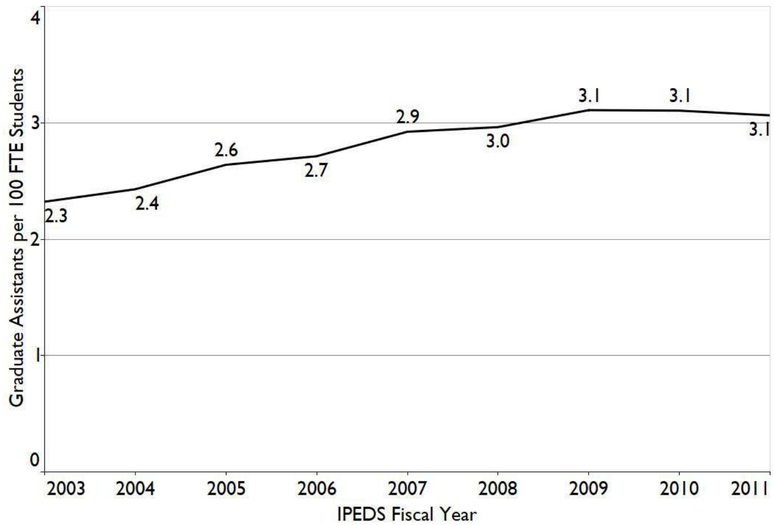

Figure 9. Ratio of graduate assistants to FTE students (*ta*) at Texas public universities.

Figure 10 demonstrates that the overall ratio of teaching assistants to FTE students is highest at Research institutions and lowest at Master's universities. All THECB types displayed significant increases in this ratio varying from a 13% increase at Research universities to a 46% increase at Doctoral universities.

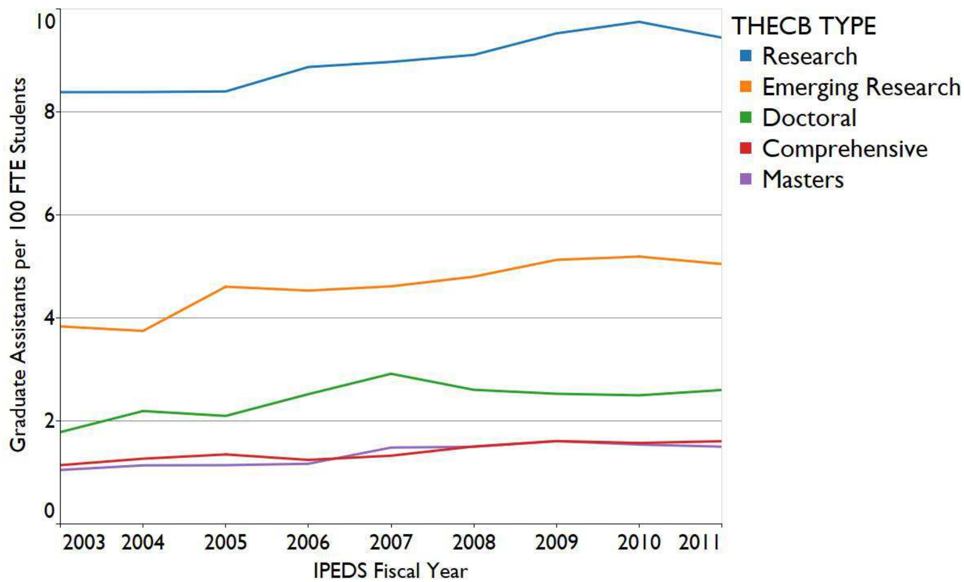

Figure 10. Ratio of graduate assistants to FTE students (*ta*) at Texas public universities by THECB institution type.

Independent Variables—Salaries and Benefits.

The second set of independent variables in the Martin and Hill model are measures of average staff salaries and benefits. Figure 11 presents the statewide average of the first of these, staff salaries (*staffsal*). Average salaries climbed moderately in real terms from 2003 to 2006 (3%) before declining back to 2003 levels by 2011. Overall, staff salaries almost exactly matched changes in the CPI from 2003 to 2011.

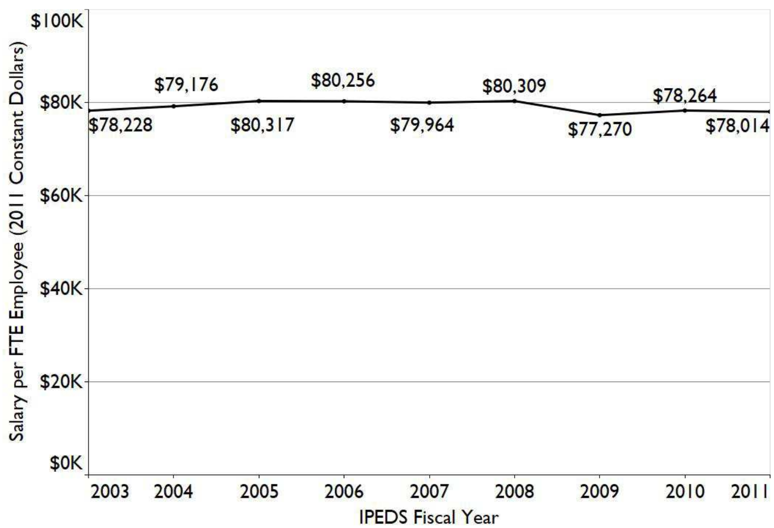

Figure 11. Average real staff salaries (*staffsal*) at Texas public universities.

Figure 12 demonstrates how staff salaries changed by THECB category. Staff salaries at Emerging Research institutions substantially lagged the rest of the sector for the entire period. Average staff salaries were highest at Master's level institutions. Average staff salaries increased substantially at Research universities—from $78,725 to $82,315 (5%)—and moderately at Master's universities (2%). The change in Research institution salary expenditures follows their pattern of increases in total expenditures: rapid increases in the years immediately following tuition deregulation to a new, higher plateau. In contrast, average staff salaries at the remaining three THECB institution types declined and display little evidence of change immediately following tuition deregulation.

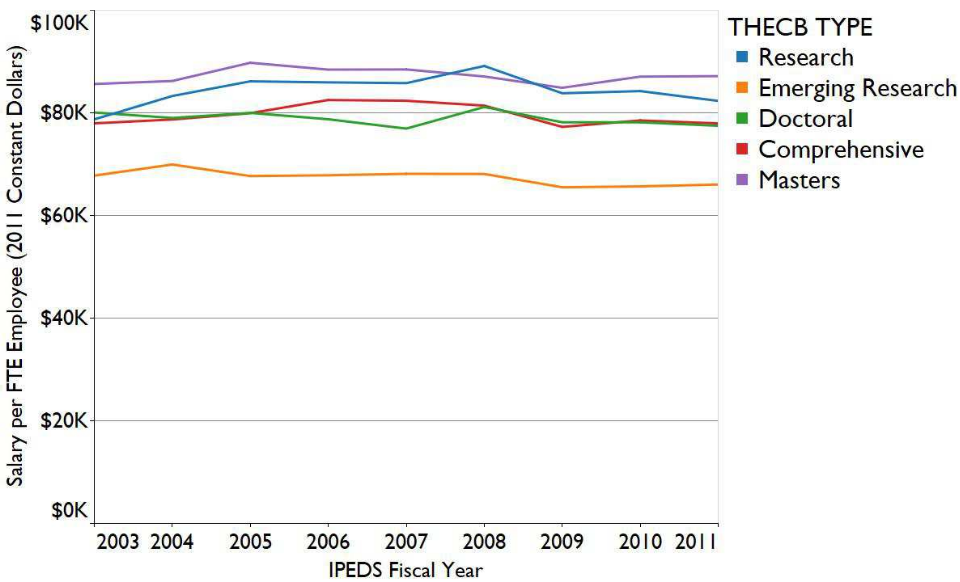

Figure 12. Average real staff salaries (*staffsal*) at Texas public universities by THECB institution type.

The second compensation variable Martin and Hill define is average benefits per FTE staff member (*benstaff*). Figure 13 presents the statewide average of these benefit costs, which increased in real terms from \$18,747 to \$19,181 (2%).

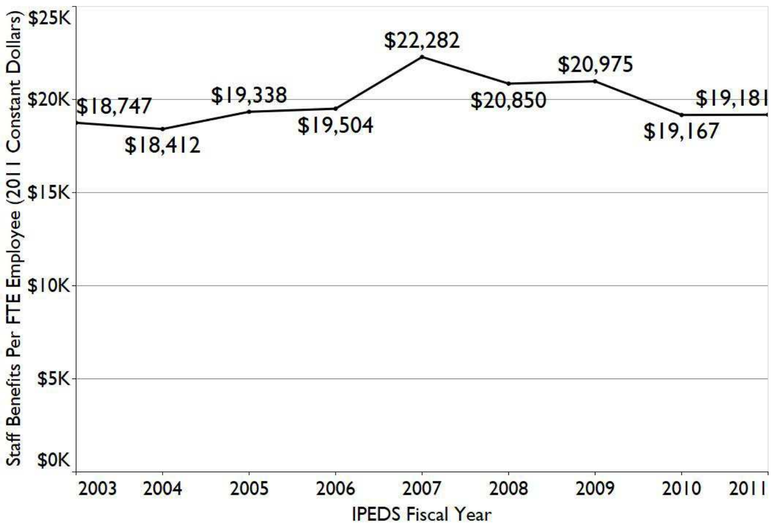

Figure 13. Average real staff benefits (*benstaff*) at Texas public universities.

Figure 14 demonstrates how staff benefits changed by THECB institution type. As with staff salaries, staff benefits at Emerging Research institutions were substantially lower than other university types. Three institution types—Research, Emerging Research, and Doctoral—saw small real increases in benefit expenditures, while Master's universities were unchanged and Doctoral universities saw a substantial drop of -8%. The data demonstrate, however, that the real cost of staff benefits was not stable during this period. In particular, there was a large spike from 2006 to 2007 in four of the five university types.

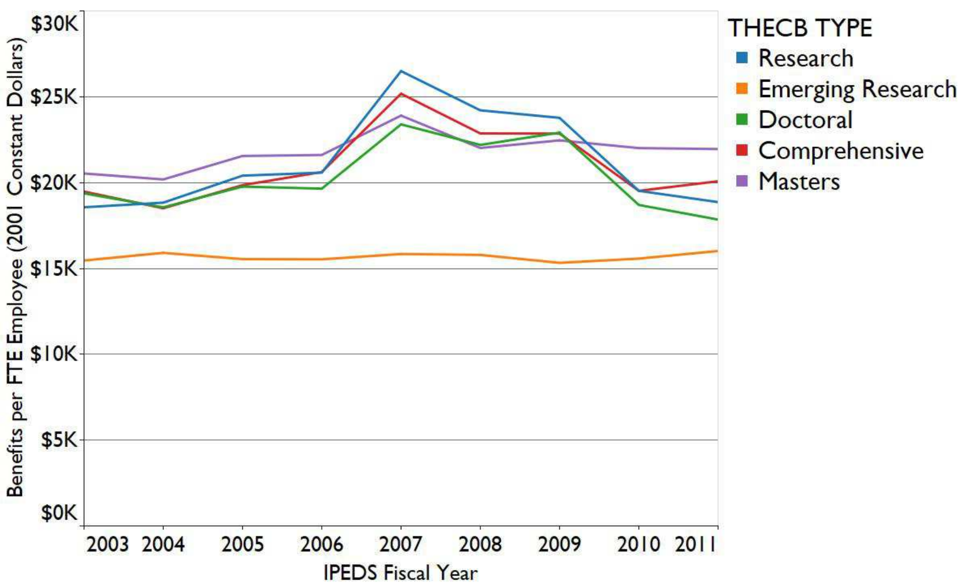

Figure 14. Average real staff benefits (*benstaff*) at Texas public universities by THECB institution type.

Independent Variables—Faculty Measurements.

Martin and Hill use the FTE student measure *ftestu* described above to construct a set of four faculty measurements describing the contract status of academic employees. The first of these variables is the ratio of contract faculty per 100 FTE students (*cf*). Figure 15 presents the statewide average of this variable for the study period. Perhaps surprisingly, there were fewer contract faculty per FTE student in 2011 than at the beginning of the study period (- 3%) after reaching a peak in 2008.

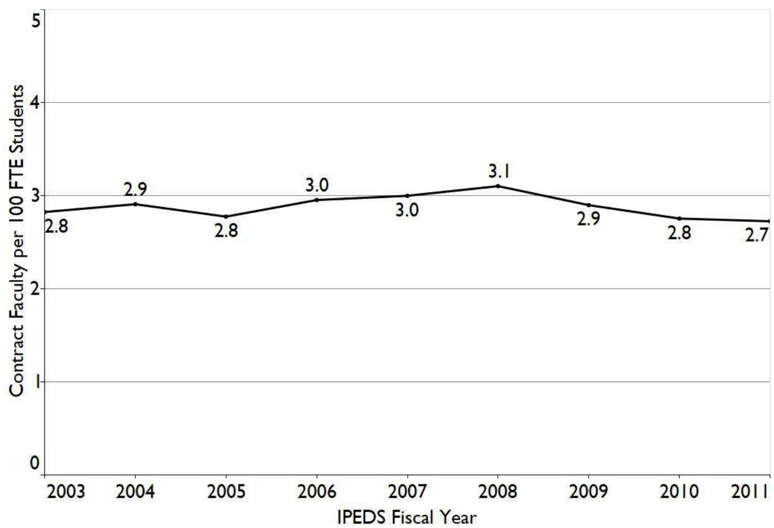

Figure 15. Contract faculty per 100 FTE students (*cf*) at Texas public universities.

Figure 16 demonstrates that the usage of contract faculty varied substantially by sector. Contract faculty use at Master's universities jumped in 2004 to over twice the level of the lowest usage type (Research) before declining to 1.8 times greater by 2011. Doctoral institutions also saw a decline in contract faculty, from 2.9 per FTE student to 2.3. Aside from the surge and decline in contract faculty usage at Master's universities and the decline in usage at Doctoral universities, the use of contract faculty during this period was relatively stable.

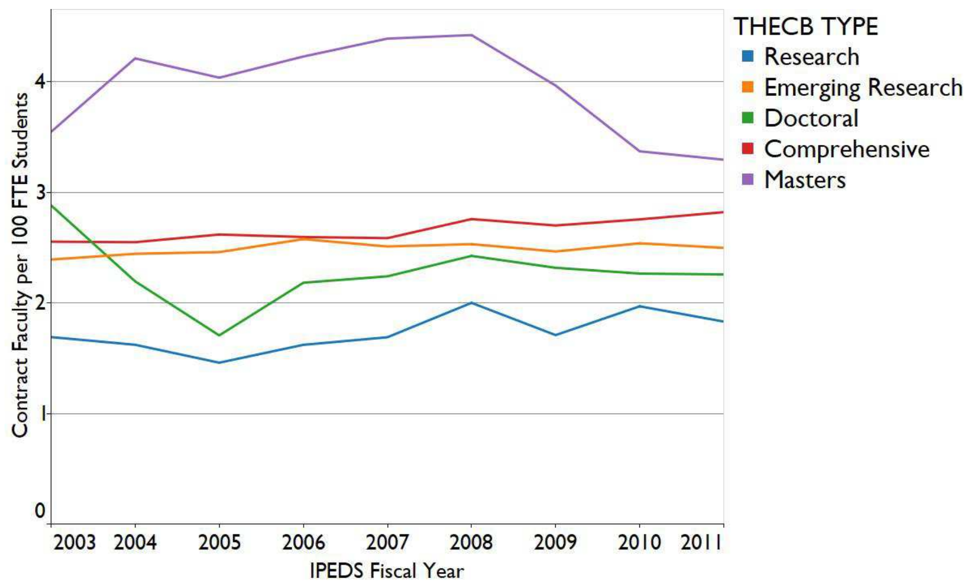

Figure 16. Contract faculty per 100 FTE students (*cf*) at Texas public universities by THECB institution type.

The next faculty measure Martin and Hill define is the ratio of part-time faculty per 100 FTE students (*ptf*). Figure 17 presents the statewide average for this variable. As with the contract faculty indicator, use of part-time faculty peaked in 2008 and was lower in 2011 than 2003 (-7%).

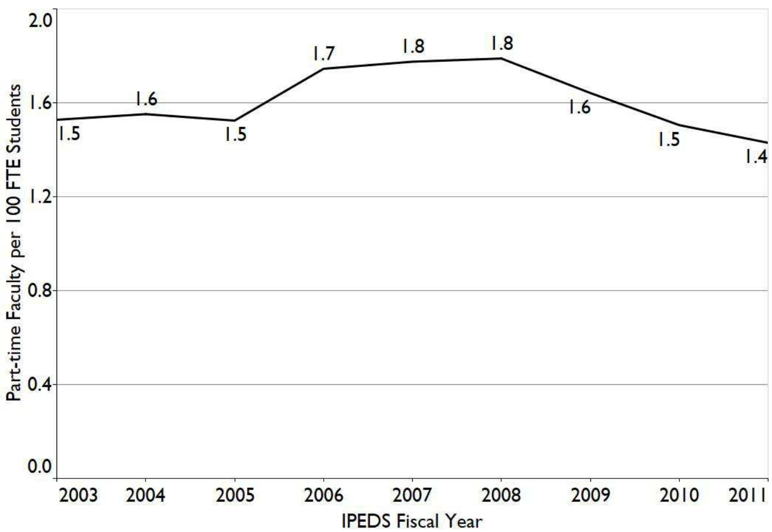

Figure 17. Part-time faculty per 100 FTE students (*ptf*) at Texas public universities.

Figure 18 presents part-time faculty by THECB institution type. The surge then decline of contract faculty at Master's institutions is repeated here among part-time faculty per FTE student. The overall decline in contract faculty at Doctoral institutions, however, did not occur among the part-time faculty. In addition, from a low bar, Research institutions displayed increasing part-time faculty, from 0.4 per FTE student to 0.6.

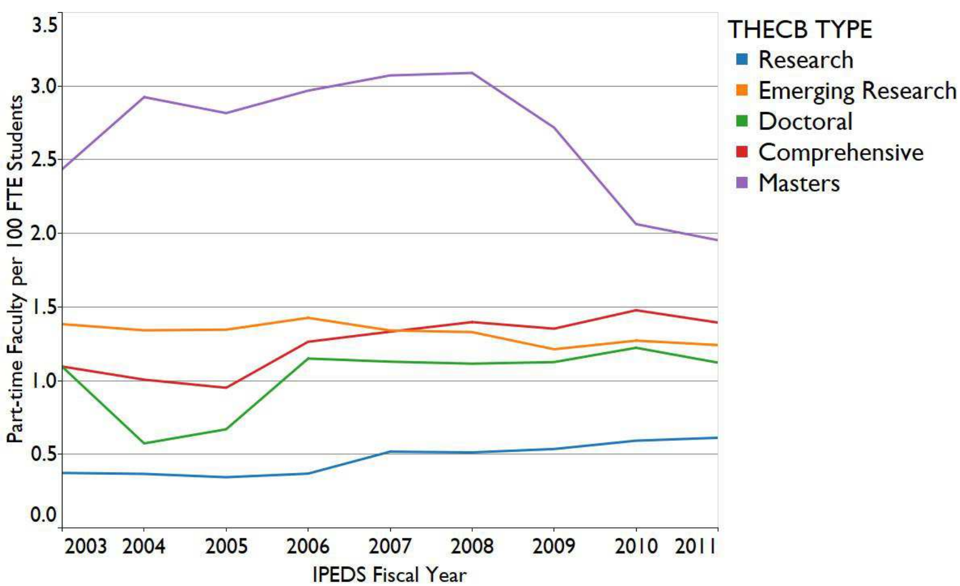

Figure 18. Part-time faculty per 100 FTE students (*ptf*) at Texas public universities by THECB institution type.

The third faculty variable in the Martin and Hill model is the ratio of FTE faculty per 100 FTE students (*ftef*). Figure 19 presents the statewide average for this variable. After six years where this ratio was largely unchanged, it declined from 3.2 in 2008 to 2.8 in 2011 (-13%).

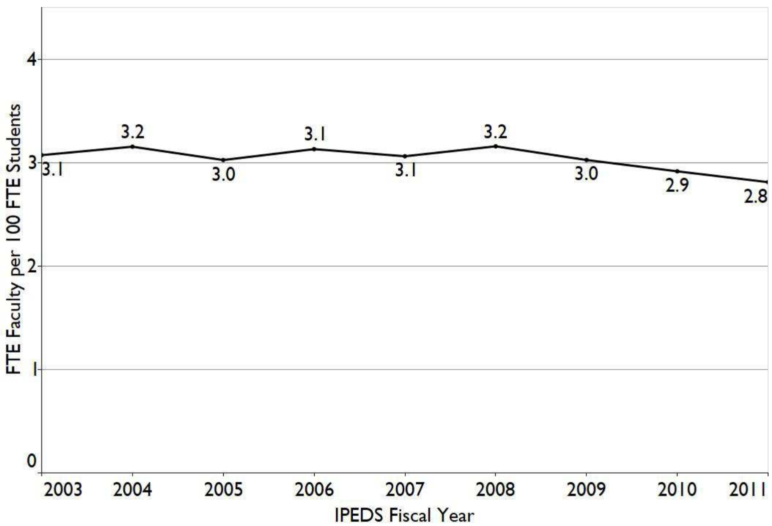

Figure 19. FTE faculty per 100 FTE students (*ftef*) at Texas public universities.

Figure 20 demonstrates how the *ftef* ratio varied by THECB institution type. The two THECB institution types with the lowest FTE faculty per student ratios in 2003 (Research and Emerging Research) both experienced modest increases from 2003 to 2011 (1% and 5% respectively). In contrast, the higher faculty to student ratios at the other three institution types declined (-22% at Doctoral universities, -8% at Comprehensive universities, and -10% at Master's universities).

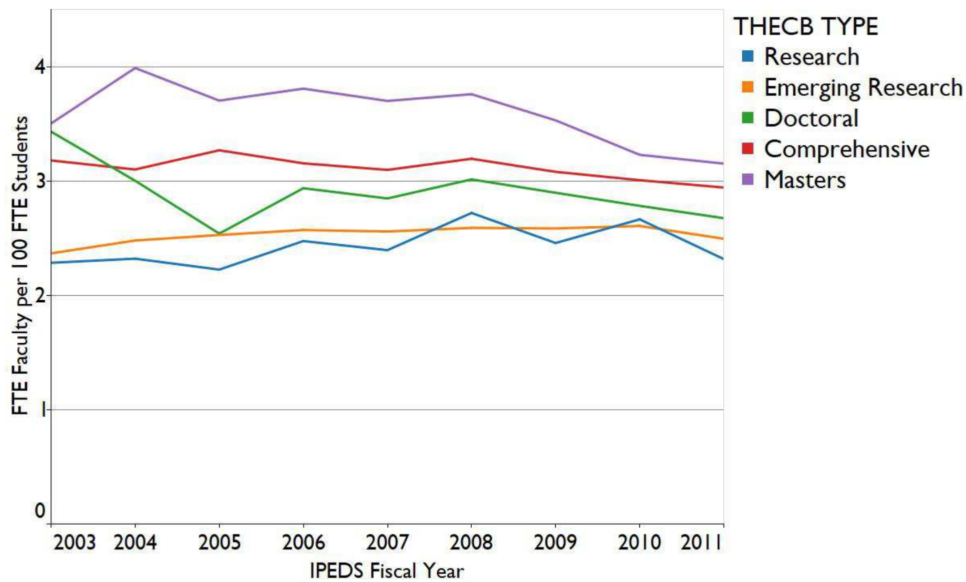

Figure 20. FTE faculty per 100 FTE students (*ftef*) at Texas public universities by THECB institution type.

The final faculty variable used by by Martin and Hill is the ratio of tenure-track faculty to non-academic professional employees (*ttad*), essentially a ratio of the relationship between the academic and non-academic activities of the institution. Figure 21 presents the statewide average of this measure, which declined rapidly during the study period (-23%).

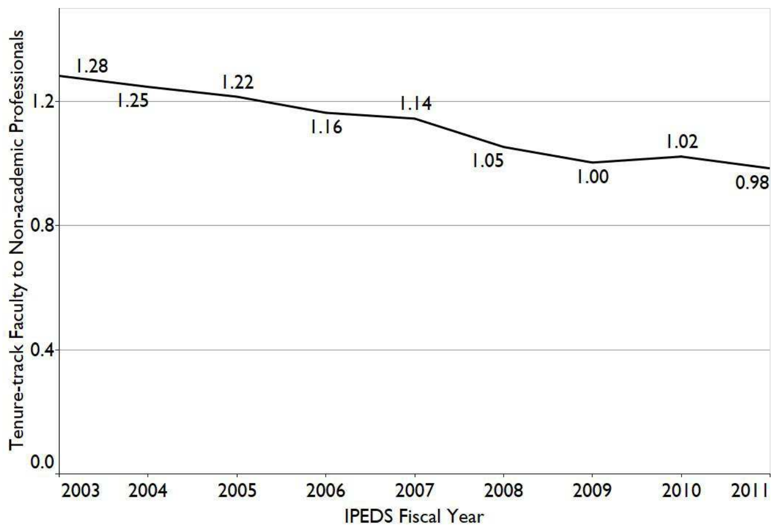

Figure 21. Tenure-track faculty per professional non-academic staff (*ttad*) at Texas public universities.

Figure 22 demonstrates that the reduction in the ratio of tenured faculty to non-academic professional staff was concentrated at the Emerging Research, Doctoral, Comprehensive, and Master's institutions—declines of -14%, -16%, -24%, and -33% respectively. In contrast, Research institutions increased their ratio of tenure-track faculty to administrators over the time period by 6%.

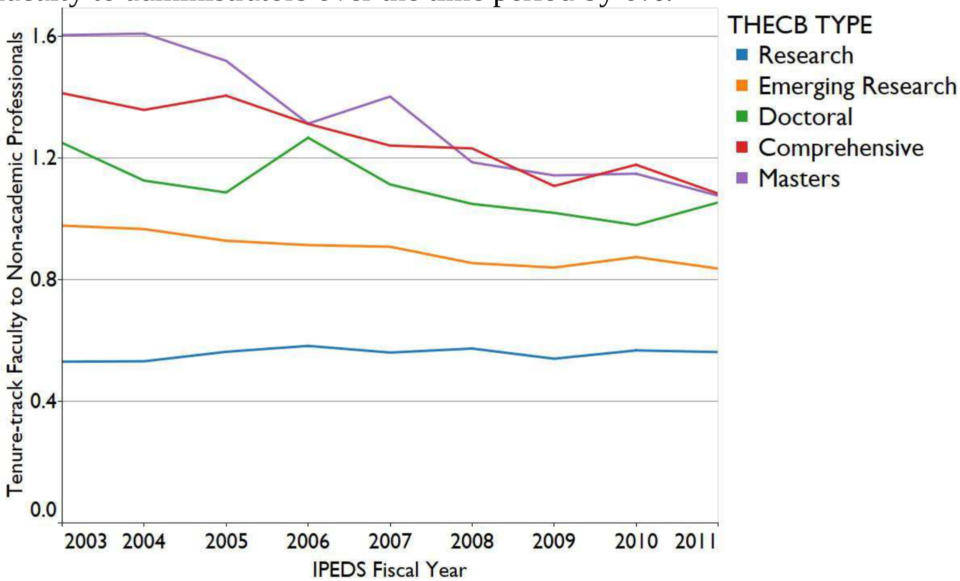

Figure 22. Tenure-track faculty per professional non-academic staff (*ttad*) at Texas public universities by THECB institution type.

Independent Variables—Staff Measurements.

The next set of variables defined by Martin and Hill categorize non-instructional staff at the institution. A total of five staffing variables are used in their model. The first of these variables is FTE non-professional employees per 100 FTE students (*ftenpro*). Figure 23 presents the statewide average of this measure. After a slow period of modest decline from 2003 to 2008 this staffing level dropped -17% from 2008 through 2011.

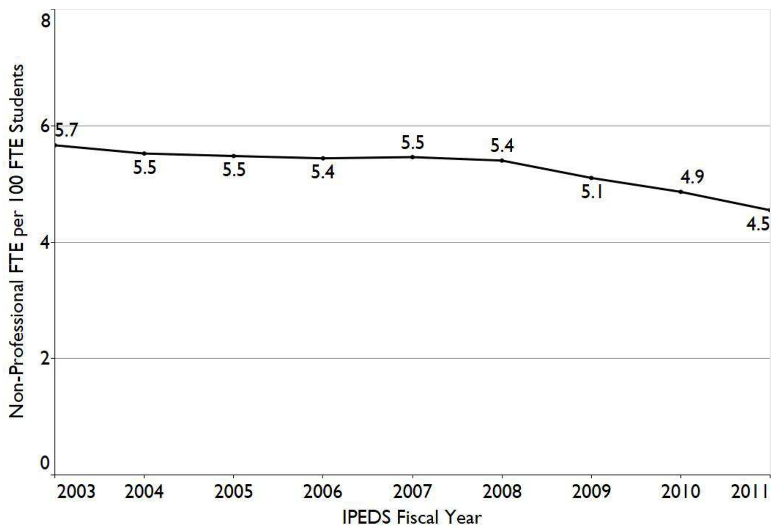

Figure 23. Non-professional FTE staff per 100 FTE students (*ftenpro*) at Texas public universities.

Figure 24 demonstrates how non-professional staffing ratios varied by THECB institution type. Four of the five THECB institution types exhibited a pattern consistent with the state average—slow decline from 2003 through 2008, with significant reductions after that fiscal year. Research institutions, on the other hand, exhibited a different pattern. Not only did they display overall staffing ratios of non-professional staff almost twice as high as the rest of the sector but these ratios were largely maintained through the study period (dropping only -5% from 2003 through 2011).

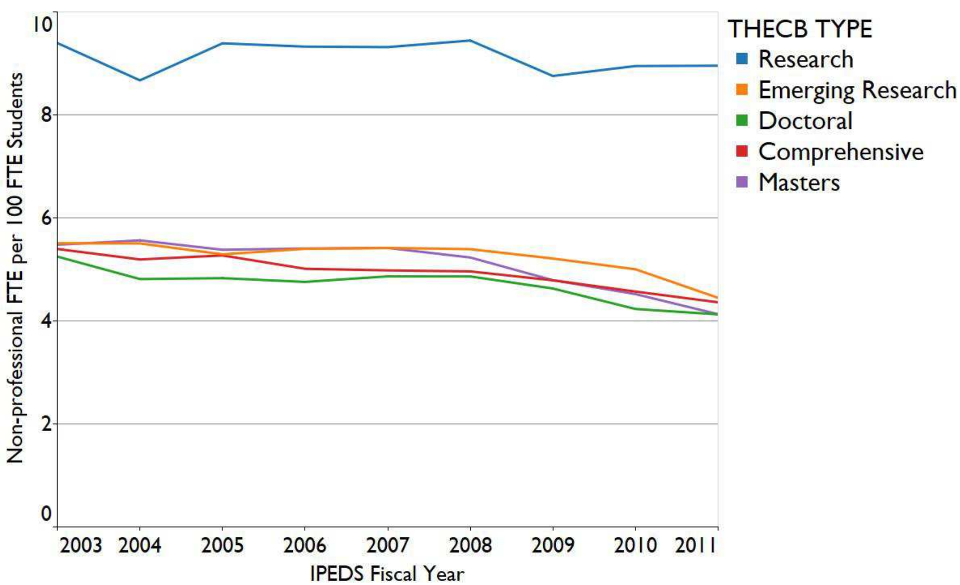

Figure 24. Non-professional FTE staff per 100 FTE students (*ftenpro*) at Texas public universities by THECB institution type.

The next variable in the Martin and Hill methodology is FTE executive and professional employees per 100 FTE students (*fteadmin*). Figure 25 presents the statewide average for this variable. From 2003 to a peak in 2009 the ratio of these employees to FTE students increased 17% before declining to an overall increase of 10% for the entire study period.

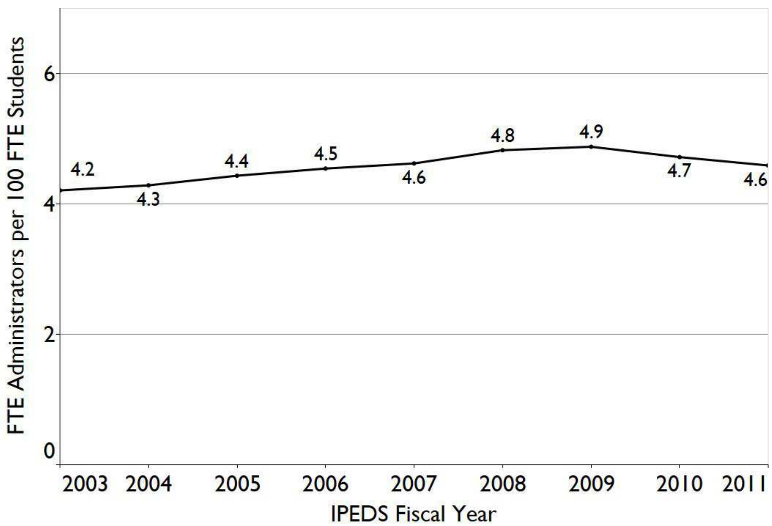

Figure 25. Executive and professional FTE staff per 100 FTE students (*fteadmin*) at Texas public universities.

Figure 26 demonstrates how the *fteadmin* variable changed by THECB institution type. As with the non-professional staffing ratio, Research universities had a substantially higher number of executive and professional employees per FTE student, close to twice the ratio of the rest of the sector. All THECB institution types displayed growth in the proportion of these administrators to students—an increase of 2% for Research, 15% for Emerging Research, 8% for Doctoral, 1% for Comprehensive, and 13% for Master's.

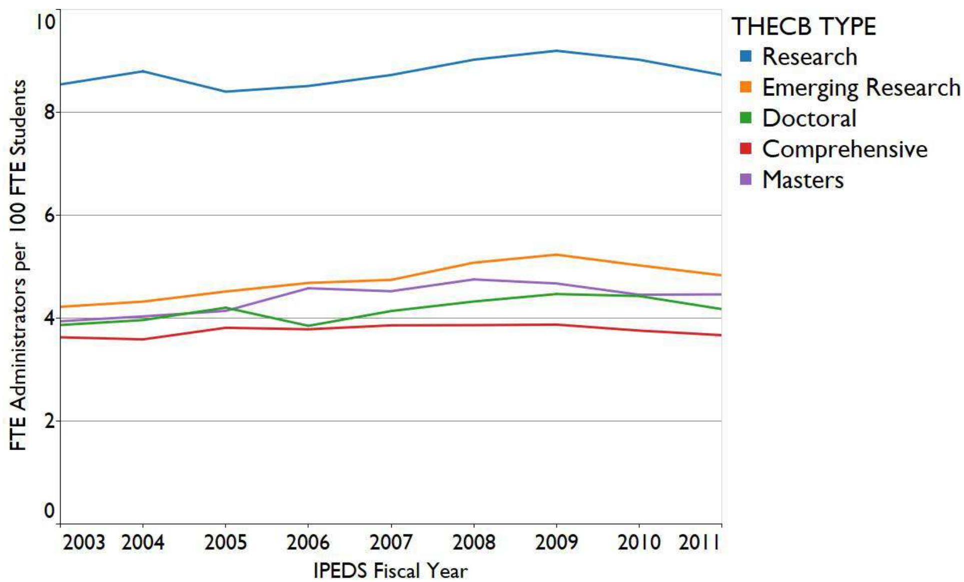

Figure 26. Executive and professional FTE staff per 100 FTE students (*fteadmin*) at Texas public universities.

The next variable in the Martin and Hill model is the average number of reporting employees per executive (*staffsize*). Figure 27 presents the statewide average for this measure. For the study period the average staff size for executives declined -17%.

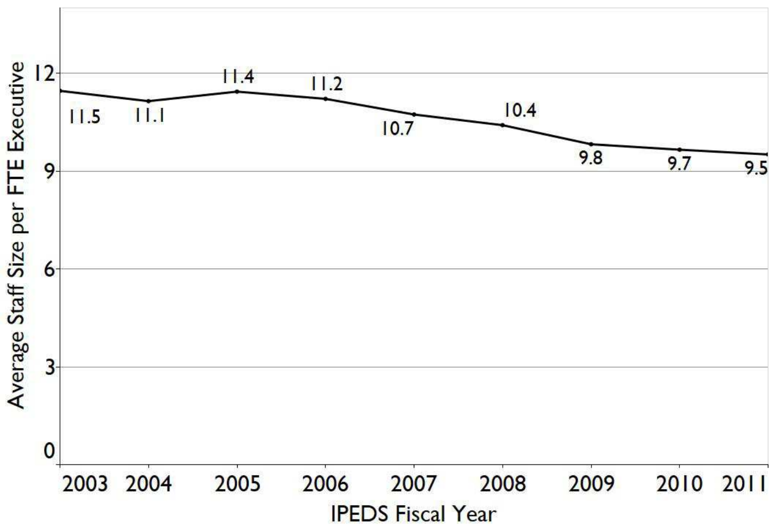

Figure 27. FTE staff per FTE executives (*staffsize*) at Texas public universities.

Figure 28 presents the *staffsize* variable by THECB institution type. Four of the five THECB institution types displayed declines in the average number of employees per manager during the study period, with Emerging Research universities demonstrating a particularly profound reduction from a peak value in fiscal year 2005 to 2011 of -43%. Research universities staff size dropped -20%, Doctoral universities -10%, and Comprehensive universities -32%. In contrast to these large reductions, Master's universities staff size increased 26% and rose from the second lowest level of staffing ratio to the highest in the sector.

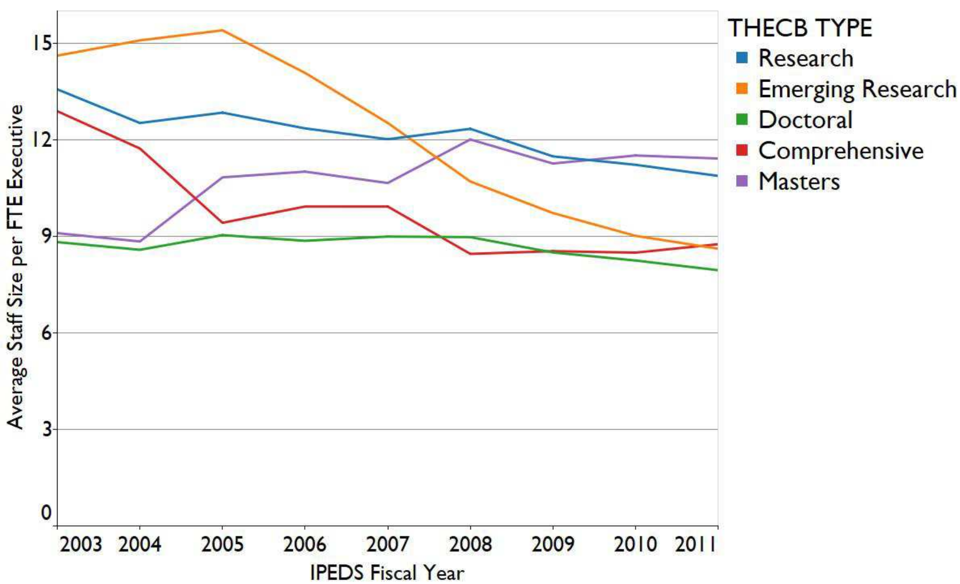

Figure 28. FTE staff per FTE executives (*staffsize*) at Texas public universities by THECB institution type.

The final two staffing variables show changes in part-time staffing levels. The first of these variables is the ratio of part-time administrators per 100 FTE students (*ptadmin*). Figure 29 presents the statewide average for this variable, which dropped a total of -37% during this period.

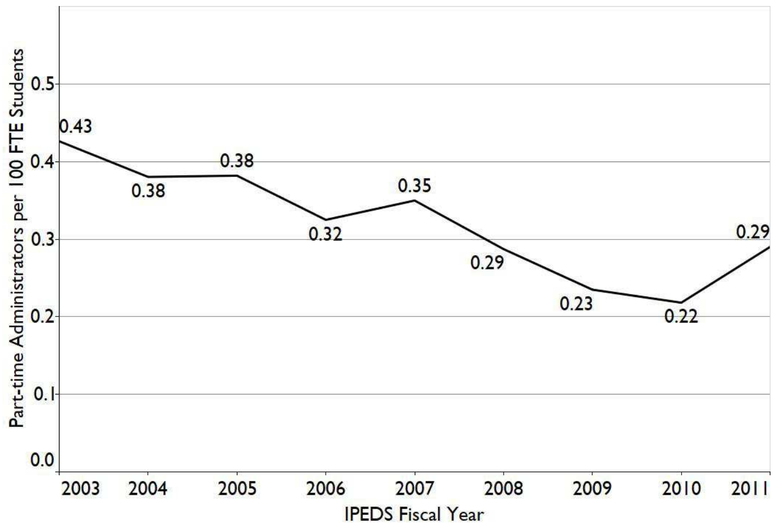

Figure 29. Part-time executive and professional staff per 100 FTE students (*ptadmin*) at Texas public universities.

Figure 30 shows changes in the part-time administrator ratio by THECB institution type. As with the other staffing variables, the ratio of part-time administrators per FTE student was substantially higher at Research institutions and increased 26% from 2003 through 2009. In contrast, part-time administrative staff per FTE student decreased at the other four THECB university types.

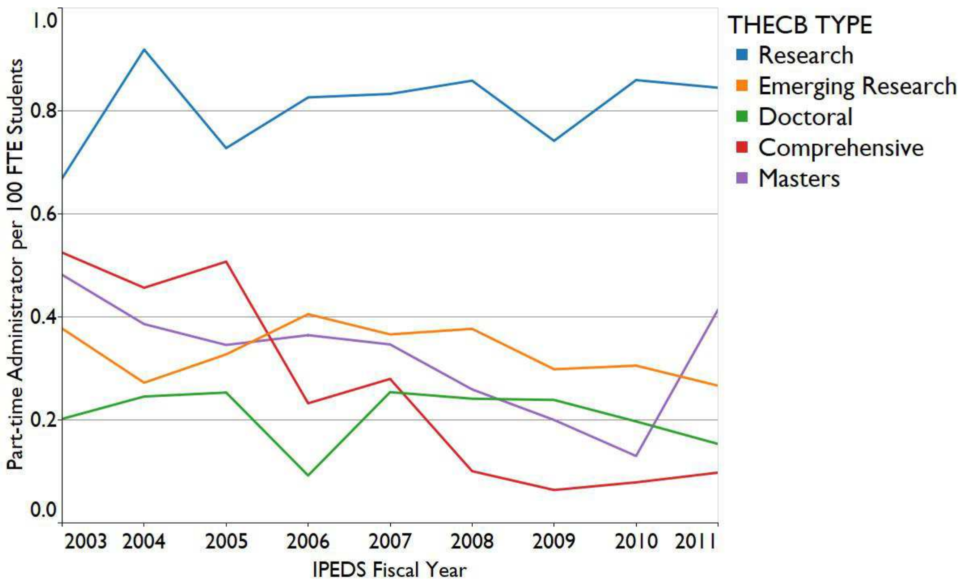

Figure 30. Part-time executive and professional staff per 100 FTE students (*ptadmin*) at Texas public universities by THECB institution type.

The final staffing variable in the Martin and Hill model is the ratio of part-time non-professional staff per 100 FTE students (*ptnpro*). Figure 31 presents the statewide average for this variable, which declined by -47% during the study period.

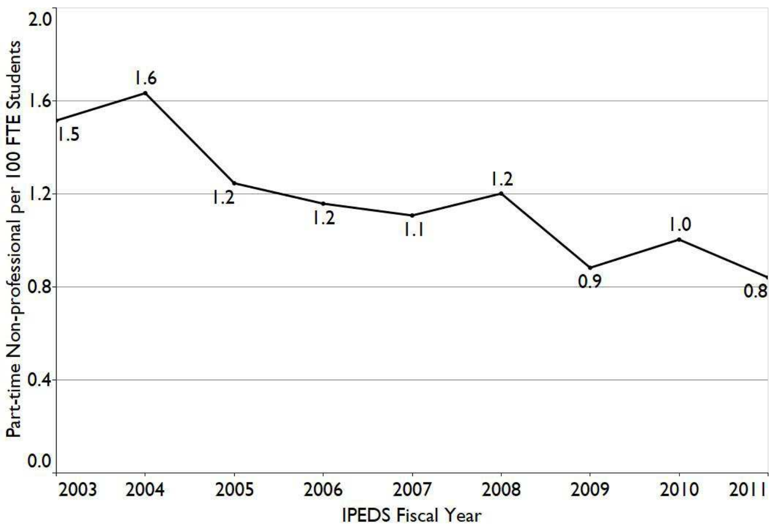

Figure 31. Part-time non-professional staff per 100 FTE students (*ptnpro*) at Texas public universities.

Figure 32 presents the change in part-time non-professional staff by THECB institution type. Research class universities are again different than the other THECB institution types in their large number of part-time non-professional staff per FTE student as well as their 12% increase in this ratio from 2003 to 2011. In contrast, the ratio of part-time non-professional staff declined at the other four THECB institution types.

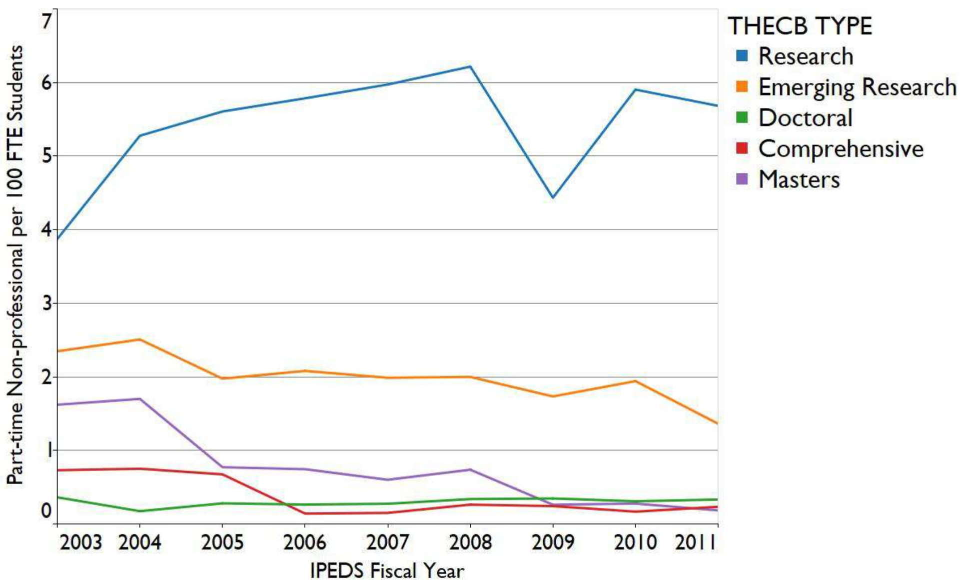

Figure 32. Part-time non-professional staff per 100 FTE students (*ptnpro*) at Texas public universities by THECB institution type.

Independent Variables—Revenue.

The final set of variables used by Martin and Hill measure three sources of university revenue per FTE student. Figure 33 presents the statewide average for total revenues per student less investment income (*rev*). From fiscal year 2003 to fiscal year 2011 *rev* expanded 9% in real dollars (but declined since 2009).

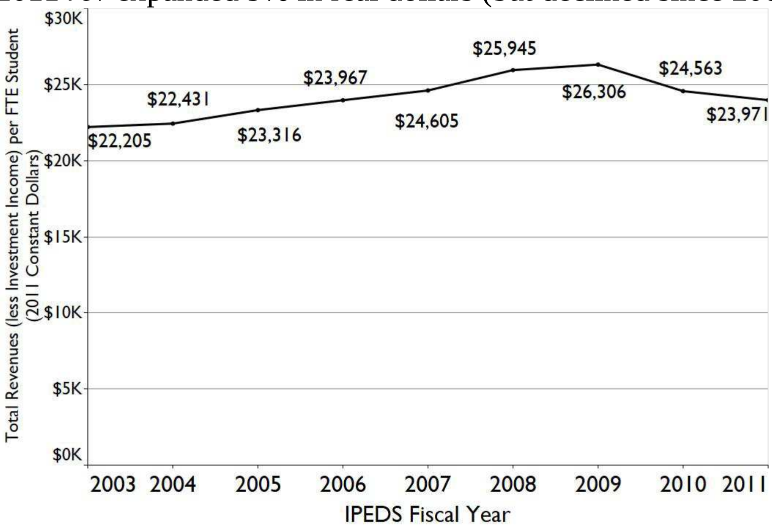

Figure 33. Total real revenue per FTE student, less investment income (*rev*) at Texas public universities.

Figure 34 presents total revenue per student by THECB institution type. While this amount increased for all university classes, the already overwhelming lead in real per-FTE student revenue at Research institutions widened dramatically in both percentage and absolute terms from 2003 through 2011, from $42,202 to $50,123 (an increase of 19%). This expansion occurred in the years immediately following tuition deregulation. Doctoral universities also experienced a major percentage increase in real revenue from $19,956 to $20,938 (19%). In contrast, Emerging Research universities raised average revenue per student from $22,587 to $23,230 (3%), Comprehensive universities from $19,956 to $20,938 (5%), and Master's universities from $20,937 to $21,740 (4%).

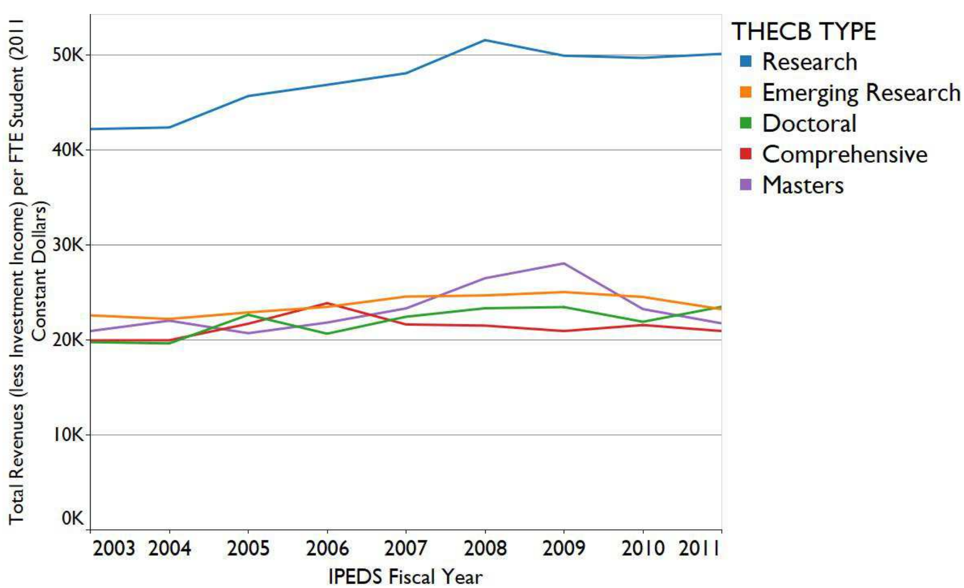

Figure 34. Total real revenue per FTE student, less investment income (*rev*) at Texas public universities by THECB institution type.

The second revenue variable used by Martin and Hill is “other” operating revenue (*other*), a subset of total revenue. Figure 35 shows the statewide average for real other revenue during the study period. Overall, other income increased 15% during the study period. While source of revenue is not available in IPEDS, the spike of other income in fiscal year 2009 correlates with the wide distribution of addition Federal funds from the economic stimulus provided by the American Recovery and Reinvestment Act.

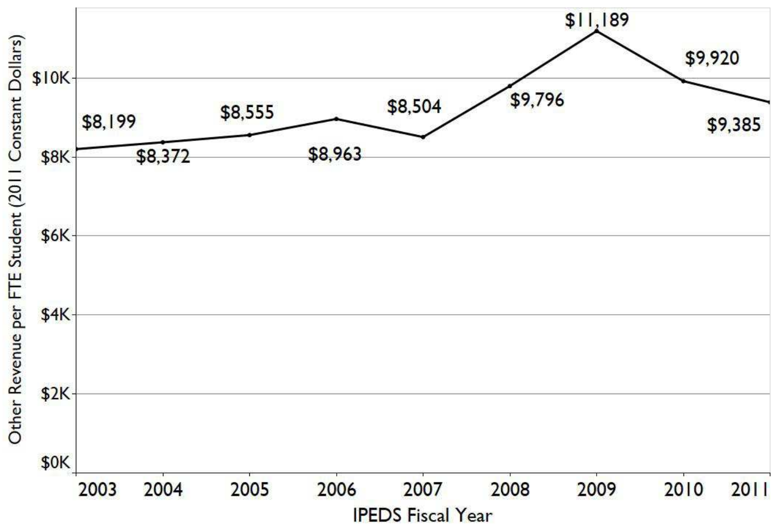

Figure 35. Real other revenue per FTE student, less investment revenue (*other*) at Texas public universities.

Figure 36 shows how other income changed during the study period by THECB institution type. The massive revenue advantage for Research universities in total revenue is also reflected in other revenue. From 2005 until 2011, other revenue at Research institutions increased from $22,163 to $28,761 (30%), faster than their rate of total revenue growth. To put that into perspective, Research universities on average generated more revenue from other sources than other institutions generated from all sources.

Doctoral universities experienced a dramatic percentage increase in real other income, from $5,763 to $9,550 (66%). Comprehensive and Master's universities displayed smaller gains from $7,348 to $8,134 (11%) and $6,617 and $6,974 (5%) respectively. Other income at Emerging Research universities actually declined from $9,258 to $8,525 (-8%).

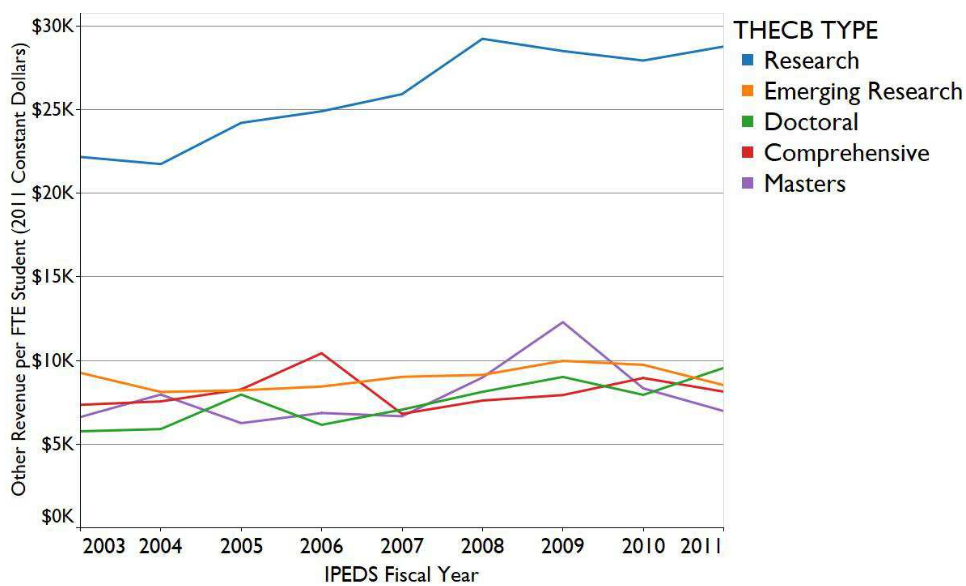

Figure 36. Real other revenue per FTE student, less interest (*other*) at Texas public universities by THECB institution type.

The final revenue variable used by Martin and Hill is investment income per FTE student (*invest*). Figure 37 presents statewide average investment income per student. (The large negative amount in fiscal year 2009 was due to the recession that began at the beginning of that fiscal year.) Overall investment income per FTE student decreased in real terms from $653 to $495 (-24%), however this masks wide fluctuations in yearly investment income (and demonstrates why removing these funds are important for understanding strategic behavior on the part of institutions).

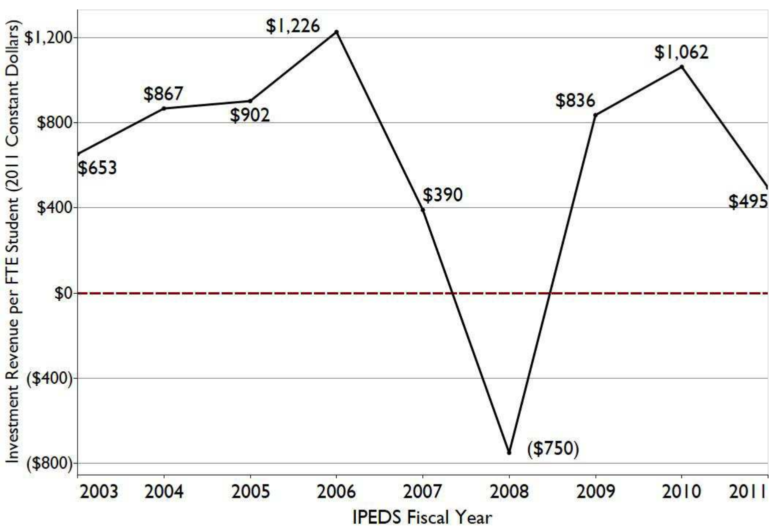

Figure 37. Real investment revenue per FTE student (*invest*) at Texas public universities.

Figure 38 presents the variation in investment income by THECB institution type. The difference between Research universities and the rest of the sector is stunning; for example, in 2011 Research universities generated $1,753 in investment income compared to the next highest institution type (Emerging Research) at $446. Research institution investment income also displays a dramatic amount of variation, from a high of $7,604 per FTE student to a low of -$6,499 during the 2008 economic crisis.

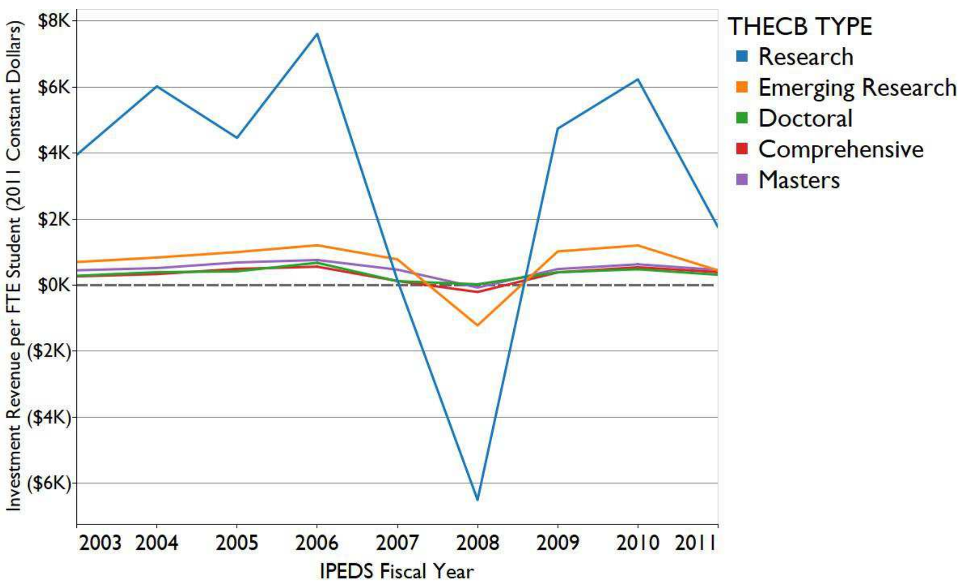

Figure 38. Real investment revenue per FTE student (*invest*) at Texas public universities by THECB institution type.

SUMMARY OF CHANGES IN THE STATEWIDE VARIABLES.

There are five major findings at the statewide level for Texas public universities following tuition deregulation. First, real expenditures per FTE student increased substantially, by 9% from 2003 through 2011. Second, this increase in expenditures occurred simultaneously with an increase in the number of FTE students (20%) and part-time students (20%) and that increase in FTE students was largely in the undergraduate category (since graduate students only increased 5%). Third, increases in enrollment and spending occurred while salaries and benefits were largely flat (0% and 2% respectively). Fourth, all of these increases were associated with increasing revenue on an FTE student basis both broadly (9%) and in other revenue (15%). In short, the scope of the public higher education sector increased dramatically both in real expenditures and enrollment between fiscal years 2003 and 2011 as tuition deregulation was implemented.

As the scope of the sector increased, substantial changes in staffing patterns occurred. On the academic side of the university, FTE faculty per FTE students dropped by -13% while contract faculty and part-time faculty dropped at a smaller rate (-3% and -7% respectively). On the non-academic side, non-professional positions, both full-time and part-time, dropped -21% and -47% respectively. In contrast to non-professional administration and faculty, executive and professional administrators per FTE student increased by 10%. The drop in non-professional staff and increase in professional staff led to a -17% decline in average staff size. Finally, the growth in professional administrators combined with the general decline in faculty per FTE student led to a decline of -23% in the ratio of tenure-track faculty to non-academic professional staff.

Variations at Research Institutions.

Research institutions displayed substantially lower levels of enrollment growth than the rest of the sector from 2003 through 2011 (6%). Enrollment growth in graduate students was similar to the rest of the sector at 4%, so the difference compared to other THECB institution types occurred due to slow growth in undergraduate enrollment. In contrast to basically flat enrollment, expenditures per student at these institutions surged. Already over two times the amount the next highest THECB institution type, expenditures at Research universities grew faster than any other sector during the study period. These expenditure increases were accompanied by massive revenue growth per student—19% in total revenues and 30% in other revenues. Consequently, the total revenue gap between Research universities and the next highest institution type increased from \$19,331 to \$26,105 following tuition deregulation.

Staffing pattern changes at Research institutions varied substantially from the rest of the sector. Full-time faculty per FTE student rose 1% instead of declining. This institution type displayed the lowest usage of contract faculty and part-time faculty while its substantially higher proportion of administrators per FTE student at Research institutions was maintained. Professional and executive staff, two times higher than the rest of the sector in 2003, increased at a lower rate of 2% through 2011. Non-professional staff, which dropped precipitously elsewhere, only declined -5% at Research universities. Part-time non-academic staff, professional and non-professional, both increased (26% and 12% respectively). Finally, the ratio of tenure-track faculty to administrators grew 6% (but remained substantially lower than the rest of the sector).

Variations at Emerging Research Institutions.

Enrollment at Emerging Research institutions increased at a greater percentage than the statewide average (25%) and graduate student enrollment increased substantially more than the statewide average (27%). The increase in student enrollments was accompanied by a modest increase in the FTE student/faculty ratio of 5% while the tenure-track to professional staff ratio declined at a lower rate than the statewide average (-14%). The only variation in non-academic staffing that deviated from the statewide average was an extraordinarily sharp decline in the average staff size variable, dropping -41% during the study period. Another major variation in this sector was a substantially lower level of average staff salaries and benefits than the other four THECB institution types. Finally, Emerging Research institutions experienced by far the lowest average increase in total revenue per FTE student of any THECB institution type, only increasing 3% from 2003 through 2011.

Variations at Doctoral Institutions.

Doctoral institutions exhibited the highest average rate of FTE student enrollment increase in the sector (28%) in addition to a large percentage increase in graduate enrollment (61%), particularly from 2009 to 2011. While student enrollments increased across the board, academic staffing levels did not keep pace as the overall FTE student to faculty ratio declined -22% (the greatest of any THECB institution type). Doctoral institutions displayed a large decline in contract faculty of -27% and a reduction of the ratio of tenure-track faculty to administrators of -16%. Their large growth in student enrollments was accompanied by the second highest rate of total revenue growth of any THECB institution type (19%).

Variations at Comprehensive Institutions.

FTE student enrollment at Comprehensive institutions grew faster than the statewide average at 22%. This enrollment increase was accompanied by the second largest decline in the ratio of tenure track faculty to administration (-24%) and the second largest reduction in staff size (-32%). Comprehensive institutions experienced the third highest growth in total revenue per FTE student.

Variations at Master's Institutions.

Overall student enrollment increases at Master's institutions followed the state average, with the exception of a lower than average decline in part-time FTE enrollment of -11%. These institutions began the study period with contract faculty and part-time faculty per FTE student ratios over twice the level of the next highest institution type.

While this staffing pattern declined during the study period, these ratios remained higher than other institutional types through 2011. These institutions experienced the highest reduction in the ratio of tenure track faculty to administration of any THECB institution type (-33%) and were the only type to see an increase in administrative staff size (26%). Total revenue increased at a lower rate than the state average (4%). One final, and rather surprising, difference was that the average salary at these institutions was the highest of any THECB institution type across the study period.

Summary of Changes in the Public Higher Education Sector from 2003 to 2011

Statewide real average expenditures per FTE student increased 9% from fiscal year 2003 to fiscal year 2011, with Research institutions growing more rapidly than other institution types (14%) and expanding their already substantial expenditure advantage compared to other THECB institution types. Salaries and benefits generally remained at a constant real level, with benefits modestly outpacing salaries. Emerging Research institutions displayed substantially lower levels of salary per FTE employee while Master's and Research institutions displayed higher levels.

As expenditures per FTE student increased, FTE student enrollments increased with growth concentrated among undergraduates. Increases in enrollment were focused in the Emerging Research, Doctoral, and Comprehensive universities while Research and Master's universities grew more slowly. Graduate student enrollment was flat overall; however, it increased at Emerging Research and Doctoral universities. Statewide part-time enrollment generally increased, however this growth did not occur at Research institutions and was more modest at Master's institutions.

Across the sector, the ratio of FTE faculty per FTE student dropped during the study period with contract and part-time faculty per FTE student dropping at lower rates and potentially indicating some switching of tenure-track to non-tenure track positions. This trend was less pronounced at Emerging Research institutions while the faculty FTE student ratio at Research institutions increased modestly

As faculty employment per FTE student declined across the sector, executive and professional administrative staff increased by 10% and non-professional administrative staff declined -21%. Research institutions, on the other hand, displayed a low level of growth among FTE faculty and FTE executive and professional staff per FTE student, however, these ratios remained far above the rest of the sector. The ratio of tenure-track faculty to FTE administrators declined at all institution types but Research universities (which experienced a 6% increase).

Chapter 5: Econometric Model Results

Chapter 5 details the results of the econometric model described in Chapter 3. It begins by interpreting the results of the five regression models deployed in this research. This analysis examines both the statistical significance and influence (as measured by the parameter estimate) of the independent variables and uses differences between the five models to identify sources of heteroscedasticity, autocorrelation, and influential outliers. Following this, the chapter presents figures that show variation from 2003 to 2011 for each of the instruments in the model by THECB institution type. It next displays figures demonstrating the total estimated real averages for Baumol and Bowen expenditures by fiscal year and the ratio of these expenditures. The chapter concludes by answering the research questions that motivate this research.

Problem Statement and Research Questions

This chapter presents the statistical results from an econometric model measuring Texas public universities expenditures following tuition deregulation. Were expenditures largely constrained by macroeconomic factors in the general labor market (the Baumol hypothesis) or do unresolved agency problems, institutional interests, and other microeconomic explanations instead explain expenditures (the Bowen hypothesis)? This study addresses two research questions.

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

PRESENTATION OF THE REGRESSION MODELS

The first section of this chapter presents the general econometric model I constructed following the methodology described in Chapter 3. Table 1 compares the standard errors for the intercept and the control variables used in the study. The parameter estimate *B* may be read as the dollars explained by a one-unit change in the parameter (or in the case of categorical control variables by being part of that category). The White standard error column (HC) reports adjustments to OLS standard errors to correct for heteroscedasticity. The Newey West column (HAC) reports adjustments to correct for heteroscedasticity and autocorrelation. The columns for heteroscedasticity and autocorrelation report differences between the OLS standard error and the HC and HAC estimators. Differences from 10% to 24% are classified as "Some," differences from 25% to 49% are classified as "Moderate," and differences of 50% or greater are classified as "High."

King and Roberts (2015) argue that applying HC standard error corrections should not be considered a model fix. Instead, differences in standard errors should be seen as evidence of model misspecification and that the proper response when confronted with differences in standard errors due to heteroscedasticity is to investigate whether modifications to the functional form of the regression equation can minimize or eliminate the non-constant variance. Differences in standard errors due to autocorrelation, on the other hand, are generally due to the OLS procedure not properly discounting the amount of information contained in serially situated observations (Horchle, 2007)—with the caveat that autocorrelation due to seasonality can be addressed through changes to the functional form of the regression equation (Box, Jenkins, & Reinsel, 1994).

Table 1: *OLS, White (HC), and Newey West (HAC) Regression Results—Intercept and Control Variables*

	Ordinary Least Squares (OLS)			*White (HC)*		*Newey West (HAC)*					
Parameter	*B*	*SE B*	*p*	*SE B*	*p*	*SE B*	*p*	*OLS to HC*	*OLS to HAC*	*Hetero.*	*Auto.*
Intercept	-8,037.32	1,971.15	<.001	2,140.50	<.001	2,804.00	.005	9%	42%	No	Moderate
Research	8,930.92	1,723.86	<.001	1,758.50	<.001	2,213.90	<.001	2%	28%	No	Moderate
Emerg. Research	1,540.74	731.54	.036	738.90	.038	887.90	.084	1%	21%	No	Some
Doctoral	82.45	373.14	.825	388.80	.832	550.20	.881	4%	47%	No	Moderate
Comprehensive	965.13	338.19	.005	401.30	.017	559.90	.086	19%	66%	Some	**High**
Year: 2011	998.72	509.95	.051	560.40	.076	553.60	.072	10%	9%	Some	No
Year: 2010	1,631.08	508.78	.002	565.20	.004	587.30	.006	11%	15%	Some	Some
Year: 2009	557.21	525.83	.290	610.20	.362	660.30	.400	16%	26%	Some	Some
Year: 2008	378.89	507.29	.456	615.40	.539	649.90	.560	21%	28%	Some	Moderate
Year: 2007	-124.05	489.28	.800	521.70	.812	568.30	.827	7%	16%	No	Some
Year: 2006	156.38	433.99	.719	523.90	.766	527.00	.767	21%	21%	Some	Some
Year: 2005	-243.24	409.79	.553	417.30	.561	409.70	.553	2%	0%	No	No
Year: 2004	-11.72	392.91	.976	438.60	.979	373.20	.975	12%	-5%	Some	No*
Model R^2	**.95**										

Notes: Parameter estimates are nominal values. Differences in standard errors between OLS and White/Newey West are classified as Some between 10% and 24%, Moderate between 25% and 50% and **High** at 50% or above. Reference values for the fixed effect variables are Master's universities and fiscal year 2003. * HAC standard error is smaller than OLS.

Three of the four institution types exhibit significant difference from the reference Master's institutions in the OLS model: Research (\$8,931, $p < .001$), Emerging Research (\$1,541, $p = .036$), and Comprehensive (\$965, $p = .005$). Doctoral institutions display little difference from the reference and their parameter has low significance ($p = .825$).

The fixed effect variables controlling for institution type exhibit virtually no increases in standard errors due to heteroscedasticity when the HC estimator is applied, indicating that THECB institution type is an effective control for underlying differences in expenditures between the universities. In contrast, the HAC estimator demonstrates that all institution-type variables exhibit increases in standard errors when autocorrelation is corrected. Accordingly, the level of significance reported by OLS for these variables should be discounted in favor that reported by the HAC estimator.

Taking into account the HAC reduced standard errors, Research universities continue to display a very high level of statistically significant deviation from Master's universities ($p < .001$) while the significance of the Emerging Research and Comprehensive institution-type fixed effect variables decline to $p = .084$ and $p = .086$, respectively. In other words, the HAC estimator suggests that there is only limited statistically significant difference between the fixed effect variables for THECB institutions other than Research universities.

The year fixed effect variables generally exhibit some heteroscedasticity with six of the eight have a difference in standard errors of 10% or greater. Fiscal years that occurred following tuition deregulation exhibit smaller standard errors when autocorrelation is accounted for, while fiscal years following tuition deregulation exhibit larger standard errors. This is evidence of discontinuity created by the policy change. Under OLS, only the parameter estimate for fiscal year 2010 displays a high level of statistical significance ($p = .005$); fiscal year 2011 displays some statistical significance

(p = .051). Adjustments made by the HAC estimator to correct for autocorrelation degrade these to p = .006 and p = .072, respectively.

Table 2 compares the parameter estimates from the OLS model with the parameter estimates generated by the Huber (M) and Yohai (MM) estimators. Recall that the M-estimator adjusts the solution of the regression equation to account for heteroscedasticity while the MM-estimator adjusts for heteroscedasticity and influential outliers.[8] The parameter estimates from the M-estimator for the THECB institution-type control variables are similar to OLS results while the MM-estimator parameter estimates are more influential than those from OLS. This difference suggests that outliers are contaminating the OLS regression results for the institution type fixed-effect variables in addition to the autocorrelation identified in Table 1. Because the BLUE quality of OLS can be easily violated due to the presence of influential outliers, this finding suggests that parameter estimates generated by the MM-estimator should be used to generate estimated values for Baumol and Bowen expenditures.

Applying the M-estimator to the yearly fixed effect variables yields both greater influence in the parameter estimates and improvements in statistical significance (an expected result given the heteroscedasticity identified by the HC estimator). The influence of the parameter estimates and their level of statistical significance jumps again using the MM-estimator, indicating that outliers also skew the parameter estimates for these variables. The increase in statistical significance for some of the fiscal year fixed effect variables when moving from OLS to the MM-estimator is substantial: 2011 (p = .051 to p = .001), 2010 (p = .002 to p < .001), 2009 (p = .290 to p = .002), and 2008 (p = .456 to p = .004) and supports using the MM-estimator to generate these values.

[8] During the generation of these model results, the PROC ROBUSTREG procedure identified a number of influential outliers and recommended the use of the MM-estimator due to these outliers.

Table 2: *OLS, Huber (M-Estimator), and Yohai (MM-Estimator) Regression Results—Intercept and Control Variables*

	Ordinary Least Squares (OLS)			*Huber (M-estimator)*			*Yohai (MM-estimator)*				
Parameter	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*OLS to M*	*OLS to MM*
Intercept	-8,037.32	1,971.15	<.001	-7,241.91	1,528.66	<.001	-6,149.38	1,629.48	<.001	-10%	-23%
Research	8,930.92	1,723.86	<.001	8,976.52	1,336.88	<.001	8,508.82	1,452.46	<.001	1%	-5%
Emerg. Research	1,540.74	731.54	.036	1,470.35	567.33	.010	1,072.30	610.25	.079	-5%	-30%
Doctoral	82.45	373.14	.825	35.60	289.38	.902	-181.39	310.41	.559	-57%	*
Comprehensive	965.13	338.19	.005	897.31	262.27	.001	561.60	287.47	.051	-7%	-42%
Year: 2011	998.72	509.95	.051	1,234.79	395.47	.002	1,418.69	423.15	.001	24%	42%
Year: 2010	1,631.08	508.78	.002	1,819.25	394.57	<.0001	1,984.65	422.55	<.001	12%	22%
Year: 2009	557.21	525.83	.290	1,033.07	407.79	.011	1,329.79	435.66	.002	85%	139%
Year: 2008	378.89	507.29	.456	787.39	393.41	.045	1,193.15	419.08	.004	108%	215%
Year: 2007	-124.05	489.28	.800	382.92	379.44	.313	613.02	402.46	.128	*	*
Year: 2006	156.38	433.99	.719	220.26	336.56	.513	368.81	358.22	.303	41%	136%
Year: 2005	-243.24	409.79	.553	-92.49	317.80	.771	11.26	333.88	.973	-62%	*
Year: 2004	-11.72	392.91	.976	51.10	304.71	.867	50.21	327.68	.878	*	*
Model R^2	**.95**			**.86**			**.73**				

Notes: Parameter estimates for Year variables are nominal values. Reference values for the fixed effect variables are Master's universities and fiscal year 2003. * Sign change in parameter estimate.

In addition to the formal control variables described above, Martin and Hill's methodology includes two instruments that measure shifting expenditures within institutions based on program scale changes (from changes in the distribution of students) and institutional cost savings (from changes in the distribution of staff). Table 3 reports the OLS results and the HC/HAC standard errors for these two instruments.

For the Scale Change instrument, the bulk of the explanatory value in the OLS model lies in the ratio of graduate assistants per FTE student (*ta*). The HC estimator indicates that this variable contains some heteroscedasticity while the HAC estimator suggests it also displays high levels of autocorrelation. Despite these issues, the level of significance of the variable remains high in all three models ($p < .001$ for OLS and $p = .002$ for HAC).

The number of full-time graduate students (*ftgrad*) displays a high level of statistical significance ($p = .029$). While the HC estimator does not change this result, the HAC estimator suggests a moderate amount of autocorrelation resulting in a substantial drop in statistical significance to $p = .110$. The *ftestu* and *ptstu* variables display low levels of statistical significance in OLS ($p = .737$ and $p = .193$) both of which are degraded under HAC. Because the sign for *ta* is positive while the sign for *ftgrad* is negative, the OLS results for the Scale Change instrument suggest a trade-off between expenditures on graduate assistants and revenues from graduate students. A negative value from this instrument would present evidence that graduate education cross-subsidizes other functions within universities.

In the Cost Savings instrument, all four variables are highly significant in OLS. Under the HC and HAC estimators, contract faculty (*cf*) and part-time faculty (*ptf*) exhibit no heteroscedasticity or autocorrelation. Full-time equivalent non-professional employment (*ftenpro*) displays some heteroscedasticity and moderate autocorrelation.

Part-time non-professional administrative employment (*ptnpro*) displays moderate levels of autocorrelation. As a result, the HAC estimator reduces the statistical significance of these two variables from a high level (p = .004 for *ftenpro* and p = .013 for *ptnpro*) to a moderate level (p = .051 for *ftenpro* and p = .059 for *ptnpro*). This result suggests that the contribution of non-professional staffing ratios to explaining university expenditures is less than the base OLS model predicts due to serially correlated variation.

The overall results of the Cost Savings instrument suggest that, while higher ratios of part-time faculty per FTE student do decrease total expenditures as expected, contract faculty are *more* expensive than tenure track faculty on a per FTE student basis. This is a surprising and interesting finding; it is possible that the substitution of contract faculty for tenure-track faculty results not in short term savings costs but rather in avoiding long-term financial constraints (and that universities pay a premium for this flexibility).

Interpretation of the administrative employee parameters is straightforward. Expenditures increase due to full-time equivalent non-professional employment per FTE student while part-time employment reduces expenditures.

Table 3: *OLS, White (HC), and Newey West (HAC) Regression Results— Scale Changes and Cost Savings*

Instrument Parameter	*Ordinary Least Squares (OLS)* *B*	*SE B*	*p*	*White (HC)* *SE B*	*p*	*Newey West (HAC)* *SE B*	*p*	*OLS to HC*	*OLS to HAC*	*Hetero.*	*Auto.*
Scale Changes											
ftestu	-0.015	0.044	.737	0.041	.711	0.049	.757	-9%	9%	No	No*
ftgrad	-0.59	0.27	.029	0.29	.044	0.37	.110	8%	36%	No	Moderate
ptstu	-0.090	0.069	.193	0.050	.074	0.074	.223	-27%	7%	No*	No
ta	714.23	148.63	<.001	183.20	<.001	232.10	.002	23%	56%	Some	**High**
Cost Savings											
cf	950.25	391.36	.016	389.70	.015	385.00	.014	0%	-2%	No*	No
ptf	-1,043.79	290.83	<.001	315.70	.001	304.60	.001	9%	5%	No	No
ftenpro	398.10	138.27	.004	152.60	.010	202.60	.051	10%	47%	Some	Moderate
ptnpro	-208.50	83.31	.013	89.12	.020	110.10	.059	7%	32%	No	Moderate
Model R^2	**.95**										

Notes: Parameter estimates are nominal values. Differences in standard errors between OLS and White/Newey West are classified as Some between 10% and 24%, Moderate between 25% and 50% and **High** at 50% or above. * HC/HAC standard error is smaller than OLS.

Table 4 compares the parameter estimates for the Scale Changes and Cost Savings instrument for the OLS model and robust regression estimators. In the Scale Change instrument, the graduate assistant variable remains highly statistically significant, however using the MM-estimator reduces the influence of its parameter estimate from $B = 714.23$ to $B = 465.26$. Application of the MM-estimator also reduces the statistical significance and influence of expenditures attributable to full-time graduate enrollment ($p = .029$ to $p = .154$ and $B = -0.59$ to $B = -0.32$). In contrast, the MM-estimator improves the statistical significance and influence of part-time student enrollment ($p = .193$ to $p = .033$ and $B = -0.090$ to $B = -0.12$). Both results indicate the presence of heteroscedasticity and influential outliers.

All four variables in the Cost Savings instrument are highly statistically significant in the OLS model as in well as in the robust regressions. The influence of full-time equivalent, non-professional staff (*ftenpro*) decreases from $B = 398.10$ to $B = 258.90$ when the MM-estimator is applied. The substantial increase in influence for contract faculty (*cf*) ($B = 950.25$ to $B = 1{,}251.15$) and for part-time faculty (*ptf*) ($B = -1{,}043.79$ to $B = -1{,}284.79$) suggests that these variables are subject to both heteroscedasticity and influential outliers in the OLS model and supports the use of the MM-estimator to generate estimated expenditure values for these variables.

Table 4: *OLS, Huber (M-Estimator), and Yohai (MM-Estimator) Regression Results—Scale Changes and Cost Savings*

	Ordinary Least Squares (OLS)			*Huber (M-estimator)*			*Yohai (MM-estimator)*				
Parameter	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*OLS to M*	*OLS to MM*
Scale Changes											
ftestu	-0.015	0.045	.737	-0.035	0.035	.386	-0.025	0.037	.490	100%	67%
ftgrad	-0.59	0.27	.029	-0.35	0.21	.097	-0.32	0.22	.154	-41%	-46%
ptstu	-0.09	0.069	.193	-0.095	0.054	.077	-0.12	0.055	.033	5%	31%
ta	714.23	148.63	<.001	539.04	115.26	<.001	465.26	122.92	<.001	-25%	-35%
Cost Savings											
cf	950.25	391.36	.016	1,129.62	303.51	<.001	1,251.15	327.56	<.001	19%	32%
ptf	-1,043.79	290.83	<.001	-1,174.00	225.54	<.001	-1,284.79	245.19	<.001	12%	23%
ftenpro	398.10	138.27	.004	338.35	107.23	.002	258.90	114.93	.024	-15%	-35%
ptnpro	-208.50	83.31	.013	-238.20	64.61	<.001	-209.01	68.09	.002	14%	0%
Model R^2	**.95**			**.86**			**.73**				

Note: Parameter estimates are nominal values.

Finally, the Martin and Hill methodology contains four instruments used to determine the effect of Baumol and Bowen effects. Table 5 shows these instruments. The Compensation instrument measures the relationship between expenditures and salaries and benefits. In the base OLS model, both of these variables are highly significant ($p < .001$ and $p = .001$). The parameter estimates suggest that one dollar of salary is equivalent to 2.8 dollars of benefits in explaining expenditures.

The HC estimator suggests there is some heteroscedasticity in the salary variable while the HAC estimator suggests that both variables in the Compensation instrument display substantial autocorrelation (not a surprising result given the low level of employee attrition at universities and the relationship previous year salary has on the following year). This autocorrelation degrades the statistical significance of the variables using the HAC estimator. The *staffsal* variable remains highly significant ($p < .001$ to $p = .006$) while the significance of the *benstaff* variable drops from $p = .001$ to $p = .062$.

Two of the four variables in the Productivity instrument are highly significant in the OLS model: full-time administrators per FTE student (*fteadmin*) ($p < .001$) and part-time administrators per FTE student (*ptadmin*) ($p = .007$). Both ratios are associated with increased expenditures. Employing the HC estimator results in higher standard errors for the full-time administrator variable suggesting some heteroscedasticity exists; however, since the statistical significance of *fteadmin* remains unchanged at $p < .001$ there does not appear to be a need to include a quadratic term for this variable in the functional form of the model (as Martin and Hill employ).

Table 5: *OLS, White (HC), and Newey West (HAC) Regression Results—Baumol and Bowen Instruments*

Instrument	*Ordinary Least Squares (OLS)*			*White (HC)*		*Newey West (HAC)*					
Parameter	*B*	*SE B*	*p*	*SE B*	*p*	*SE B*	*p*	*OLS to HC*	*OLS to HAC*	*Hetero.*	*Auto.*
Salary and Benefits											
staffsal	0.069	0.016	<.001	0.018	<.001	0.025	.006	14%	57%	Some	**High**
benstaff	0.16	0.047	.001	0.049	.002	0.062	.012	5%	32%	No	Moderate
Productivity											
ftef	-714.78	409.22	.082	397.40	.073	456.20	.118	-3%	11%	No *	Some
fteadmin	1,363.74	205.63	<.001	238.10	<.001	253.00	<.001	16%	23%	Some	Some
ptadmin	758.97	277.54	.007	292.40	.010	297.60	.011	5%	7%	No	No
staffsize	-3.42	14.66	.816	17.92	.849	26.820	.899	22%	83%	Some	**High**
Revenue											
rev	0.69	0.057	<.001	0.070	<.001	0.092	<.001	-13%	61%	No*	**High**
other	-0.54	0.064	<.001	0.080	<.001	0.097	<.001	-14%	50%	No*	**High**
invest	-0.074	0.079	.351	0.089	.406	0.101	.466	-12%	28%	No*	Moderate
Governance											
ttad	555.44	535.13	.300	623.70	.374	588.00	.346	17%	10%	Some	Some
Model R^2	**.95**										

Notes: Parameter estimates are nominal values. Differences in standard errors between OLS and White/Newey West are classified as Some between 10% and 24%, Moderate between 25% and 50% and **High** at 50% or above. * HC standard error is smaller than OLS.

The full-time equivalent faculty ratio is on the edge of statistical significance in the OLS model; however, this variable displays some autocorrelation and its statistical significance is diminished in the HAC estimator ($p = .082$ to $p = .118$). Finally, the ratio of staff size to number of administrators displays very low statistical significance ($p = .816$). Because it also demonstrates some heteroscedasticity and a high degree of autocorrelation (the highest variance in standard errors in this study) the low level of significance for this variable is further degraded in the HAC estimator ($p = .899$).

Two variables in the Revenue instrument in the OLS model are highly significant: total revenue less investment income (*rev*) and other income (*other*) (both $p < .001$). Investment income (*invest*) displays a low level of statistical significance ($p = .351$). As in Martin and Hill's results, *rev* is associated with increases in expenditure while *other* is associated with declines. In the model, core revenues function as an omitted variable. Since the sign of *rev* is positive, this indicates that an increase in total revenue leads to a larger increase in expenditures than the same amount of increase in core revenue. Similarly, an increase in the *other* revenue variable implies that revenue from these sources results in lower levels of expenditures than core revenue. These results could be related to the relative long-term stability of different revenue sources.

None of the three variables in the Revenue instrument display increased standard errors due to heteroscedasticity; in fact, all display *reduced* standard errors in the HC estimator.[9] All three variables display moderate to high levels of autocorrelation; however, this autocorrelation does not degrade the statistical significance of the total revenue or other income variables (both of which remain at $p < .001$).

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[9] It is possible these variables represent an example of a rare form of heteroscedasticity with non-constant, lower variance in the middle of the distribution.

The Governance instrument has one variable—the ratio of tenure-track faculty to administrators. The variable does not display statistical significance in the OLS model and this lack of significance is degraded further by heteroscedasticity. Performing a quadratic transformation on this variable (as suggested by Martin and Hill) does not result in an increase in statistical significance and its quadratic functional form does not display the global minimum of Martin and Hill's model. This finding merely indicates that an increase in the ratio of tenure track faculty to FTE students increases expenditures with some diminishing returns.

Table 6 presents the robust regression estimators for the instruments measuring Baumol and Bowen effects. The first of these is the Compensation index. The M-estimator suggests that some heteroscedasticity exists in the salary variable (confirming the analysis of standard errors). More significantly, the MM-estimator suggests that the OLS parameter estimates for this variable are substantially inflated by the presence of influential outliers and this reduces the influence of the salary variable (B = 0.07 to B = 0.051) and the benefits variable (B = 0.16 to B = 0.12). Since Baumol effects are captured only by this instrument, this result suggests that the OLS regression solution overestimates Baumol expenditures due to outliers and provides a strong reason to use the MM-estimator in generating estimates for Baumol and Bowen values.

Table 6: *OLS, Huber (M-Estimator), and Yohai (MM-Estimator) Regression Results—Baumol and Bowen Instruments*

	Ordinary Least Squares (OLS)			*Huber (M-estimator)*			*Yohai (MM-estimator)*				
Parameter	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*OLS to M*	*OLS to MM*
Salary and Benefits											
staffsal	0.069	0.016	<.001	0.058	0.012	<.001	0.051	0.013	<.001	-16%	-25%
benstaff	0.16	0.047	.001	0.14	0.036	<.001	0.12	0.038	.001	-8%	-21%
Productivity											
ftef	-714.78	409.22	.082	-885.68	317.36	.005	-1,052.22	337.99	.002	24%	47%
fteadmin	1,363.74	205.63	<.001	1,479.64	159.47	<.001	1,531.14	178.13	<.001	8%	12%
ptadmin	758.97	277.54	.007	640.19	215.23	.003	496.68	229.18	.030	-16%	-35%
staffsize	-3.42	14.66	.816	-13.73	11.37	.227	-21.65	12.75	.090	301%	532%
Revenue											
rev	0.69	0.057	<.001	0.68	0.044	<.001	0.68	0.050	<.001	-1%	-1%
other	-0.54	0.064	<.001	-0.52	0.050	<.001	-0.49	0.055	<.001	-4%	-9%
invest	-0.074	0.079	.351	0.0082	0.061	.893	0.082	0.070	.239	*	*
Governance											
ttad	555.44	535.13	.300	981.03	415.00	.018	1,261.18	468.71	.007	77%	127%
Model R^2	**.95**			**.86**			**.73**				

Notes: Parameter estimates are nominal values. * Sign change in parameter estimate.

The robust regression solutions lead to little change in the parameter estimate and statistical significance of full-time administrators per FTE student; the variable remains both significant and influential. In contrast, the robust regression estimators degrade the statistical significance and influence of the part-time administrator variable (p = .007 to p = .030 and B = 758.97 to B = 498.68) indicating that outliers skew this variable.

In contrast, application of the M-estimator leads to a dramatic increase in statistical significance (from p = .082 to p = .005) for the full-time faculty per FTE student variable and this significance is improved further by the MM-estimator (p = .002). This result raises the possibility that the functional form of *ftef* is misspecified in the model. I examined this possibility with OLS with a quadratic transformation. The resulting functional form is slightly concave upwards but expenditures explained by the non-linear form increase at a rate only slightly above linear. Given this modest change, and that implementing the MM-estimator corrects for this non-linear relationship, I opted to avoid sacrificing a degree of freedom to include this transformation in the final model.

An increase in statistical significance and influence between the OLS result and MM-estimator result of the *staffsize* variable suggests another potential misspecification in the model (p = .816 to p = .090 and B = -3.42 to B = -21.65). As with the *ftef* variable, I investigated this relationship with a quadratic transformation and it too displayed a functional form with slightly concave upwards curve. In the case of *staffsize*, however, in addition to the slight difference between the linear and non-linear versions of the independent variable the overall influence of the variable was small (explaining only $72 in expenditures per FTE student at the median value for *staffsize*). Because the MM-estimator adjusts this variable well, and because the influence of the variable is so small, I opted to preserve a degree of freedom and leave the linear term in the model (although a case could be made for dropping it entirely).

Application of the robust regression estimators to the variables in the Revenue instrument does not change the significance of *rev* and *other* variables in the instrument. There is some indication of modest skew from influential outliers in the *other* variable that reduce its influence (B = -0.54 to B = -0.49).

The final instrument in the Martin and Hill framework is Governance, represented by the ratio of tenure-track faculty to administrators (*ttad*). Martin and Hill find that this variable is highly significant in a quadratic transformation, a transformation that results in a global minimum they interpret as a "Golden Mean" for faculty to staff ratios. As with the *staffsize* and *ftef* variables, the low level of statistical significance (p = .300) in the OLS model is improved by the M-estimator (p = .018) and MM-estimator (p = .007) indicating either model misspecification or influential outliers. Accordingly, I also examined a quadratic transformation of the *ttad* variable in OLS. Unlike the *ftef* and *staffsize* variables, this transformation did not result in a statistically significant pair of variables and, unlike Martin and Hill, the functional form did not display a global minimum. The implication is that the robust regression estimators are performing as they are designed to—reducing heteroscedasticity and limiting the impact of influential outliers. A change in functional form to the variable is thus unnecessary.

ESTIMATION OF INSTRUMENT EFFECTS

This presentation of the general model establishes that the data generally display fairly low levels of heteroscedasticity and some degree of autocorrelation (expected in a balanced panel dataset). The results of the MM-estimator, however, establish that the data exhibit substantial contamination from outliers that have measurable impacts on the standard errors and influence of some of the independent variables in the model. Most critically, the outliers cause the OLS model to overstate the explanatory value of the

Compensation instrument and thus the estimate of Baumol expenditures.[10] Accordingly, this study uses the parameter estimates generated by the MM-estimator to calculate mean values of the instruments for the five THECB institution types. Since the regression equations presented above were generated using nominal values, the calculation of yearly average values also includes a transformation into 2011 constant dollars using a CPI deflator that corresponds with the Texas fiscal year.

The fixed effect variable controlling for fiscal year presents an opportunity to examine the overall trend of expenditures following tuition deregulation. Figure 39 shows these values and the difference pre- and post tuition deregulation is dramatic. Tuition deregulation appears to have led to an increase in per FTE student expenditures on the order of $1,400 at all universities from pre-deregulation expenditure levels (averaging $1,512 between fiscal years 2008 but with a spike in 2010).

[10] This insight also demonstrates the importance of interrogating a dataset with a variety of different regression techniques.

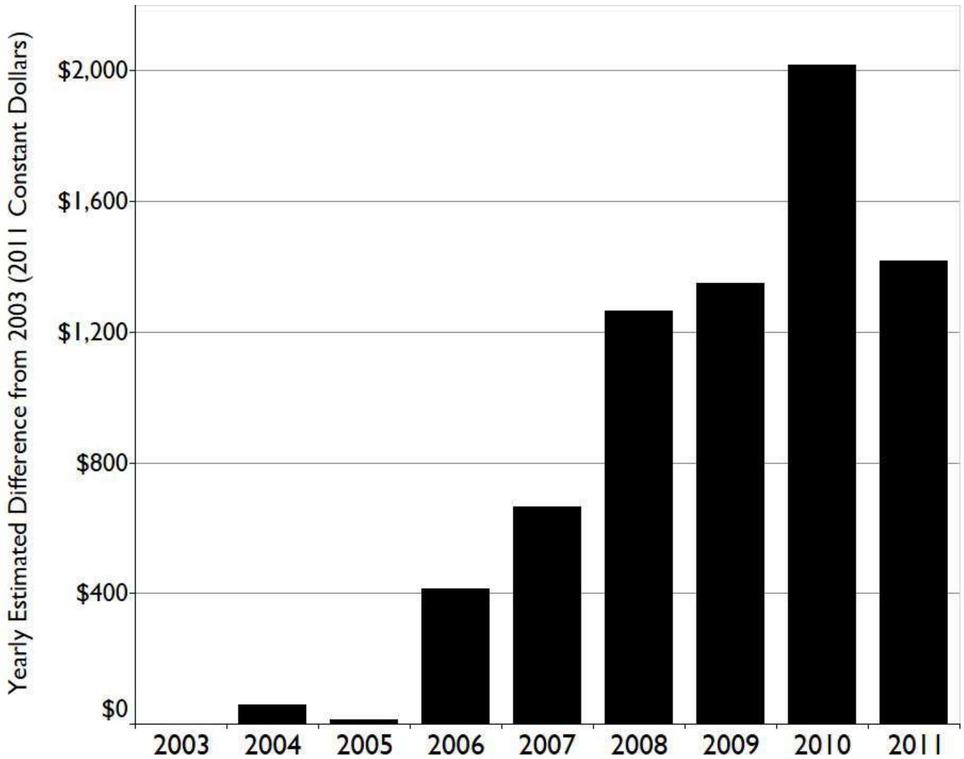

Figure 39. Estimated real expenditure change per FTE student by fiscal year, controlling for other variables.

Figure 40 presents the proportion of expenditures explained by the Scale Change instrument by THECB institution type. All estimated values of the instrument are negative. Since the variables with negative parameter estimates were not statistically significant in the MM-estimator this result suggests potential multicollinearity between the variables in the instrument. A potential interpretation of the results from this instrument is that graduate students without support cross-subsidize other functions of the university beyond expenditures required to support teaching and graduate assistants.

The Scale Change instrument displays substantial variation by research intensity across the sector, with Emerging Research and Research universities displaying a large amount of potential cross-subsidy from graduate education to elsewhere in the university.

Intriguingly, the amount of the subsidy drops rapidly during the study period at Research universities, from -$6,943 to -$4,850 (-30%). Given that these universities did not see a drop in graduate students, this drop must be explained through an expansion in support for graduate studies through increasing expenditures on teaching and graduate assistants.

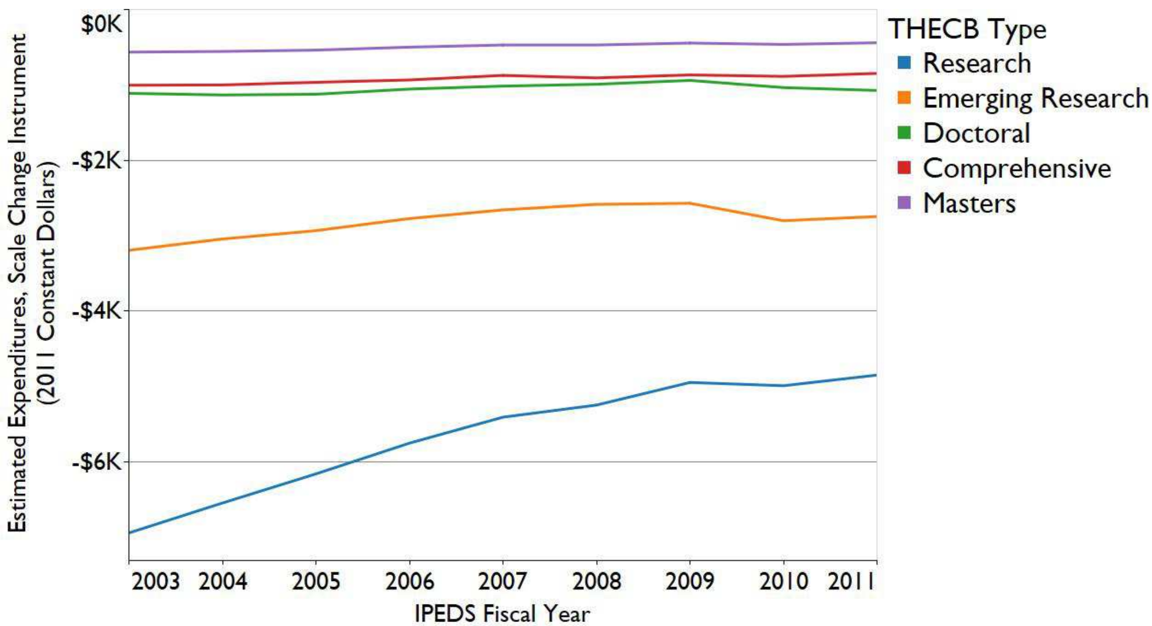

Figure 40. Estimated real expenditure changes per FTE Student due to Scale Changes by THECB institution type.

Figure 41 presents estimated values for the Cost Savings control instrument by THECB institution type. While Martin and Hill report the instrument as measuring a cost subsidy, the results from this study suggest that the variables in the instrument are related to higher levels of expenditures. This result occurs because the ratio of contract faculty to FTE students is associated with higher expenditures than the ratio of tenure-track faculty to FTE students. A potential explanation for this result is that Texas public universities have been paying a premium for shorter term labor arrangements in lieu of long-term tenure commitments on a per FTE faculty basis.

From 2003 to 2011, universities shifted dollars between faculty types and this led to a reduced amount of expenditures the instrument explains (and reflects funds shifted to other expenditures elsewhere in the institution). The expenditure drop was particularly pronounced at Research universities ($4,821 to $2,636, -45%) and Doctoral universities ($5,154 to $2,383, -54%). Smaller drops occurred at Emerging Research (-25%), Comprehensive (-37%), and Master's universities (-25%).

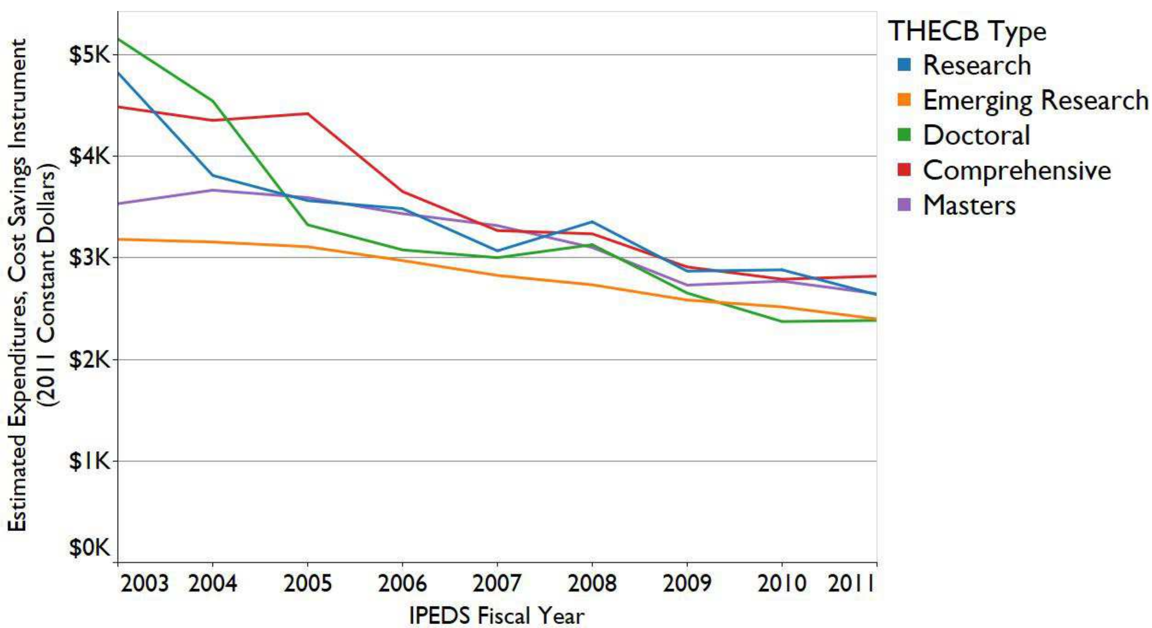

Figure 41. Estimated real expenditure changes per FTE student due to Cost Savings by THECB institution type.

Compensation accounts for both Baumol and Bowen effects in the Martin and Hill model (because data limitations do not allow these measures to be broken down by functional administrative area). Martin and Hill use a statistical correlation between compensation and staffing variables to estimate that 51% of benefit costs and 52% of salaries are due to Baumol effects. Departing from this approach, I created an OLS regression model to determine the proportion of salaries and benefits that could be explained by staffing patterns. This model finds a weaker Bowen relationship to benefits and salaries than that reported by Martin and Hill: 30% for benefits and 39% for salaries. In the Martin and Hill methodology, salaries and benefits not explained by Bowen effects are presumed to be due to Baumol effects, so the remainder of the predicted values of *benstaff* and *staffsal* are distributed to Baumol effects (70% and 61%).

Figure 42 presents the amount of expenditures explained by the Compensation instrument. There is little variation in overall expenditures by THECB institution type, with the exception of a lower proportion of explained expenditures at Emerging Research universities. From 2003 to 2011, all institutions exhibited real drops in expenditures explained by the Compensation instrument. These drops were of similar scale, ranging from 13% at Research universities to 19% at Emerging Research universities. This result suggests that Baumol expenditures diminished during the period of this study (although there is no clear discontinuity to support a difference before and after tuition deregulation). The results also suggest that there is little differentiation in macroeconomic effects across university types.

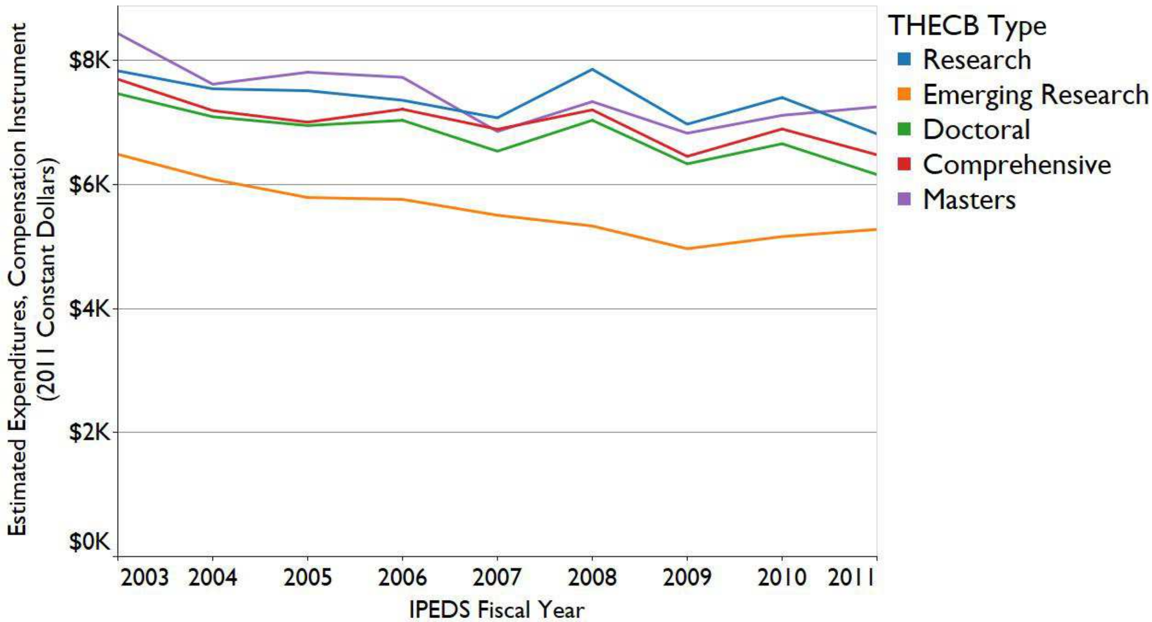

Figure 42. Estimated expenditure changes per FTE student due to Compensation by THECB institution type.

The final three instruments measure various proposed Bowen effects. Figure 43 presents the Revenue instrument, the most important of the three. Unsurprisingly, Research universities display much higher absolute estimated levels of expenditures explained by total revenue. During the study period, the proportion of expenditures explained by this instrument declined for all institution types, ranging from a drop of -7% at Research universities to -14% at Comprehensive universities. This drop reflects the rise in other revenue than total revenue (shown in Figure 35 and Figure 36).

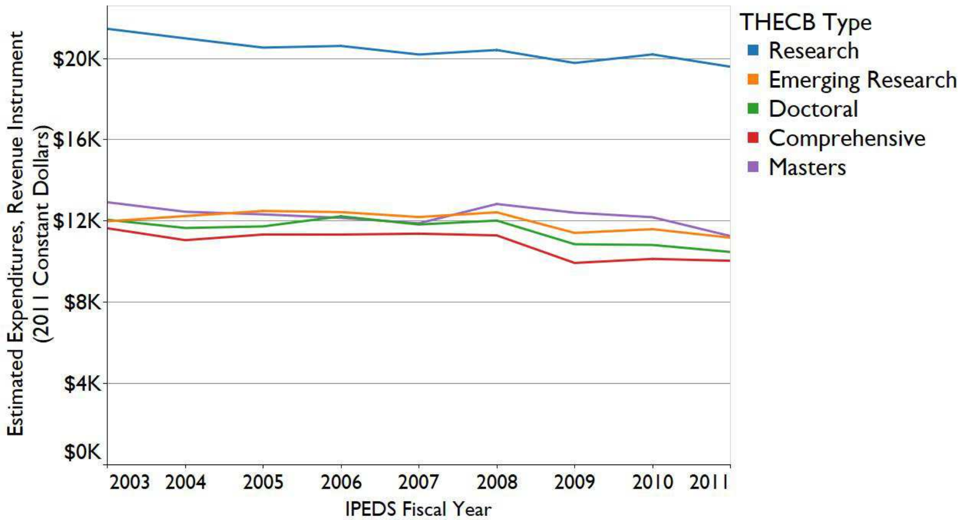

Figure 43. Estimated real expenditure changes per FTE student due to Revenue by THECB institution type.

The large expenditure difference between Research institutions and the rest of the sector is also apparent in the proportion of expenditures explained by the Productivity instrument, displayed in Figure 44. There is also an intriguing discontinuity for these universities following tuition deregulation, with a sharp decline from $15,848 to $11,107 (-30%) in expenditures. Over the study period Emerging Research universities declined -17%, Doctoral universities declined -6%, and Comprehensive and Master's universities declined -2%. The decline in dollars explained by this instrument is correlated with research intensity as measured by THECB institution type. The role of full-time administrators per FTE student in explaining expenditures declined following tuition deregulation, particularly at Research universities. Thus, the popular view of the role of "administrative bloat" in increased expenditures when revenues increase is not apparent in this study.

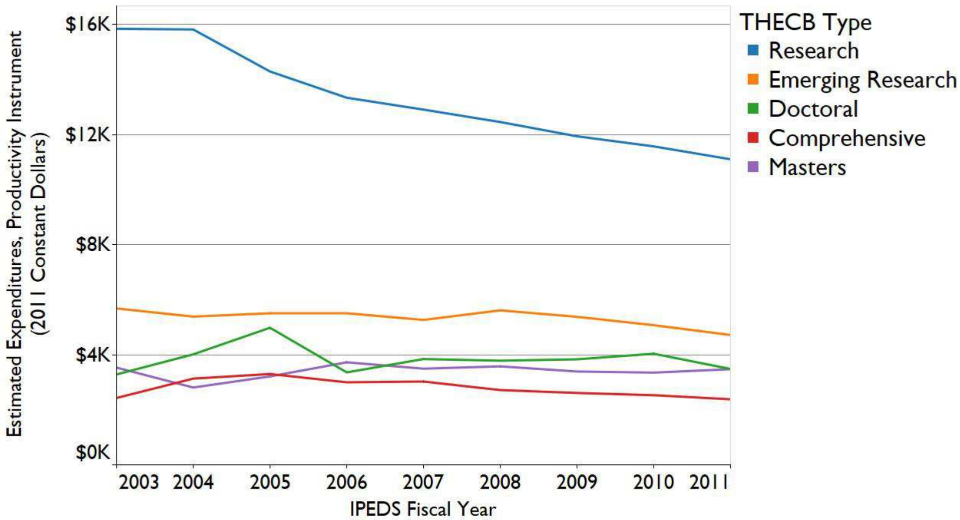

Figure 44: Estimated real expenditure changes per FTE student due to Productivity by THECB institution type.

The Governance instrument is presented in Figure 45. All university types displayed reductions in the proportion of expenditures explained by the ratio of tenure-track faculty to administrators. At the beginning of the study period there was a wide spread of dollars explained by this instrument, in reverse order of research intensity. All university types displayed declines in the dollars explained by this instrument over the study period, ranging from -28% at Research universities to -55% at Master's universities and these declines appear to be leading to convergence across the entire sector. The relatively low level of expenditures explained by this instrument, combined with the lack of support for a quadratic function with a global minimum, means this research does not support Martin and Hill's contention that there is a "Golden Mean" balancing the tenure-track faculty and professional administration and that ameliorates potential agency abuse from both parties.

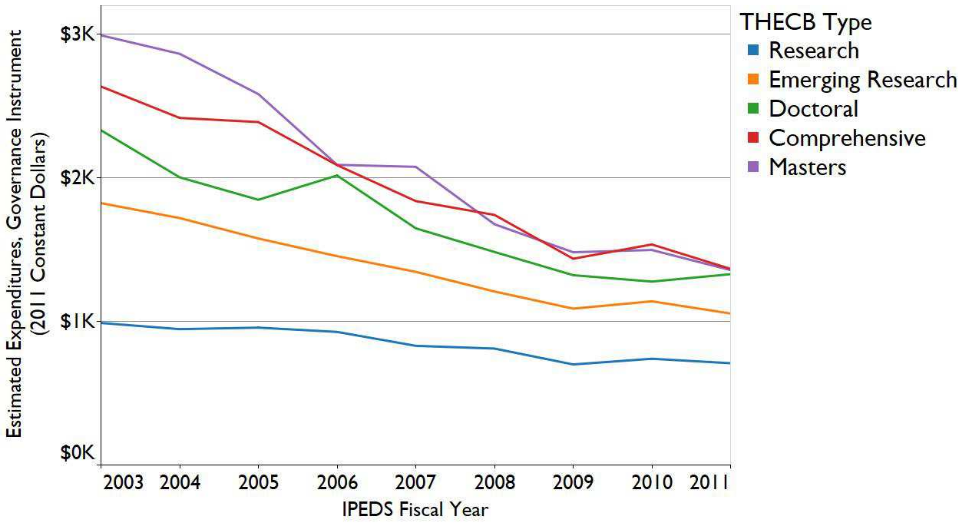

Figure 45: Estimated real expenditure changes per FTE student due to Governance by THECB institution type.

ESTIMATING TOTAL BAUMOL AND BOWEN EFFECTS

Figure 46 presents total real estimated Bowen expenditures during the study period. Dollars explained by Bowen expenditures declined for all university types during the study period. These declines ranged from -14% at Emerging Research universities to -18% at Research universities. Figure 47 presents total estimated Baumol effects for the study period. Baumol expenditures also declined across the sector from -13% at Research universities to -19% at Emerging Research universities.

These drops were balanced by an increase in explained dollars by the fiscal year fixed effect term and the reduction in negative explained dollars in the Scale Change instrument. This establishes that, during the period when tuition was deregulated at Texas public universites, increases in revenue were used to diminish existing subsidies from graduate education to the rest of the instituition rather than increase either Baumol or Bowen expenditures.

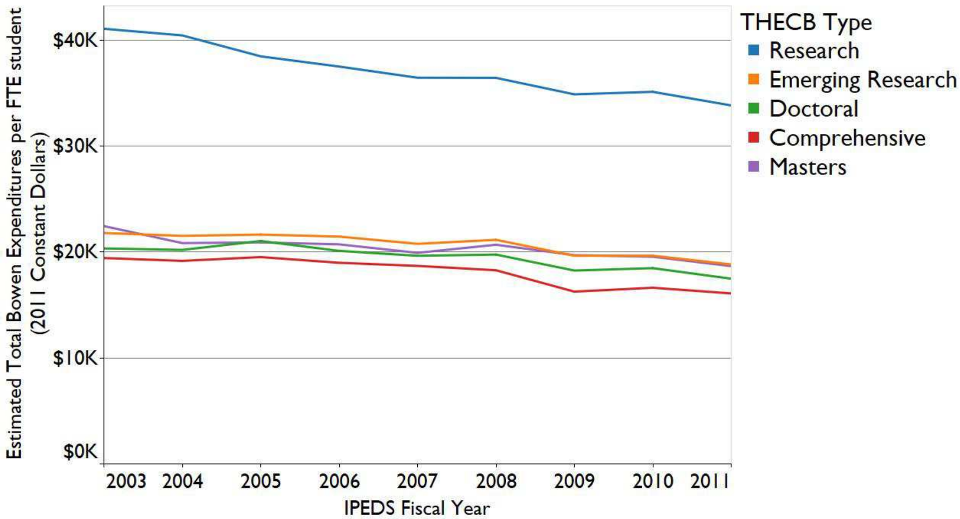

Figure 46: Estimated real expenditure changes per FTE student due to Bowen effects.

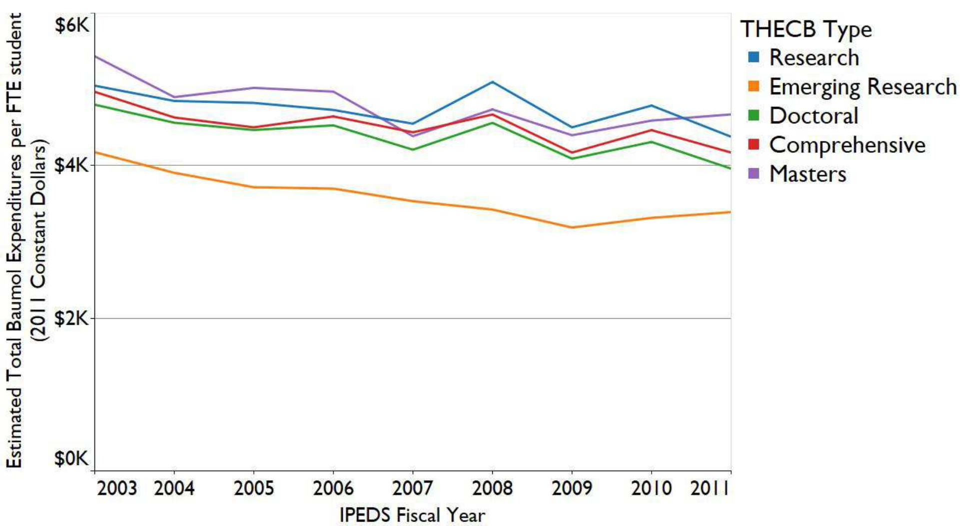

Figure 47: Estimated real expenditure changes per FTE student due to Baumol effects.

Figure 48 presents the Bowen/Baumol ratio and demonstrates the substantial difference of these expenditures by THECB institution type, a difference that persists across the study period. THECB institution types with a stronger research focus display higher levels of Bowen expenditures relative to Baumol expenditures than other THECB institution types. These ratios range from a high of 8.4 at Research universities to a low of 3.7 at Master's universities. Bowen expenditures relative to Baumol expenditures increased at Emerging Research (6%) and Doctoral institutions (4%) and decreased at Research (-5%), Master's, (-3%), and Comprehensive (-1%) institutions. These results suggest that institutions aspiring to greater research intensity devote proportionally more resources to Bowen expenditures during periods of increasing expenditures while those with fixed missions (either high or low research intensity) see a relative increase in the proportion of Baumol expenditures.

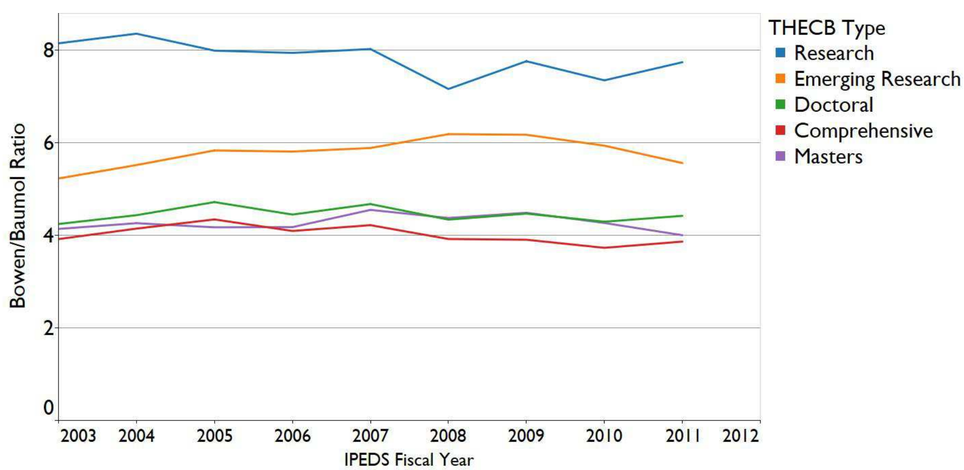

Figure 48. Bowen-to-Baumol ratio.

INVESTIGATING MULTICOLLINEARITY

Given the functional form of the model—multiple indicators combined into single instruments—I wanted to examine the sources of multicollinearity this specification has the potential to create. While multicollinearity does not invalidate a regression model, examining its role can aid in its interpretation, particularly values of parameter estimates. The analysis of the model presented above suggests two potential sources of multicollinearity: the relationship of full-time graduate students to graduate assistants and the relationship of contract faculty to part-time faculty.

My first test procedure was to calculate Variance Inflation Factors (VIF) in the model (after removing the nominal control variables from consideration) using the PROC REG function in SAS. Eight variables demonstrated a VIF over 10 (the threshold for indicating multicollinearity): *cf*, *ptf*, *ta*, *ftestu*, *ftgrad*, *fteadmin*, *rev*, and *other*. The *cf* and *ptf* variables are elements of the Cost Savings instrument and the *ftestu*, *ftgrad*, and *ta* variables are elements of the Scale Change instrument. The other three variables with potential multicollinearity are parts of the Revenue instrument (*rev* and *other*) and the Productivity instrument (*fteadmin*). The sources of potential multicollinearity identified in the presentation of the general model are contained in the first two instruments.

I next conducted a clustering analysis on the interval-ratio variables in the model to investigate any underlying factors that might link these variables using PROC VARCLUS. This analysis indicates the presence of seven underlying factors in the data matrix. Of particular interest is a cluster containing *ftestu*, *ta*, and *ftgrad*, a cluster containing *cf* and *ptf*, and a cluster containing *rev* and *other*. This result indicates that the multicollinearity in seven of the eight variables is explained due to interactions between with three clusters and that these interactions are contained in single instruments in the regression model. Finally, the eighth variable (*fteadmin*) is in a cluster with *ttad* (the ratio of faculty to administrators) and represents a third potential source of multicollinearity in the regression models, and one that crosses instruments. Table 7 shows these cluster groupings.

Table 7: *Cluster Groupings of Interval-Ratio Variables*

Cluster	Variables
Cluster 1	*ta, ftestu, ftgrad*
Cluster 2	*cf, ptf, ftef*
Cluster 3	*staffsal, benstaff*
Cluster 4	*ftenpro, ptadmin, ptnpro*
Cluster 5	*staffsize*
Cluster 6	*rev, other*
Cluster 7	*ttad, fteadmin*
Cluster 8	*ptstu*
Cluster 9	*invest*

Notes: Generated by PROC VARCLUS, Maxeigen = 0.7.

The final approach I used to investigate multicollinearity in the model was to implement a reduced variable version of the model. While many variable reduction techniques (such as stepwise) show significant issues in experimental tests of efficacy, using the least absolute shrinkage and selection operator (LASSO) estimation technique as implemented in PROC GLMSELECT can sharply reduce this problem (Flom & Cassell, 2007). Table 8 presents this four-variable reduced-form model.

Table 8: *Results for LASSO Regression*

Instrument	Parameter	Entry Order	*B*	*F*	*Pr>F*
Intercept			3,804.04		
Control-THECB Type	*Research*	3	4,841.48	534.18	<.001
Salary and Benefits	*benstaff*	4	0.06	39.92	<.001
Productivity	*fteadmin*	2	1,041.72	105.46	<.001
Revenue	*rev*	1	0.46	297.91	<.001

Note: Model adjusted R^2 = .88 (F < .001)

The results of the LASSO regression support the validity of the general model. The three Baumol and Bowen instruments with important predictors (Compensation, Productivity, and Revenue) are each measured by a single parameter in the reduced-form model. The inclusion of only Research as a control for THECB institution type is not a surprise given the analysis of the Class parameter estimates earlier. Neither the controls for fiscal years nor the instruments measuring Scale Changes or Cost Savings are included. The Governance instrument is unrepresented; not an unexpected result given the low influence of this instrument and the multicollinearity *ttad* exhibits with *fteadmin*.

To examine the effect of these three identified sources of possible multicollinearity I created a cross product terms for the three relationships and investigated them using OLS. The first of these equations uses *ttad* and *fteadmin*. All three elements (*ttad*, *fteadmin*, and *ttad*fteadmin*) were statistically significant. I examined the functional form of the cross-product equation generated by the OLS output in a range of values between the 25th and 75th percentiles of the variables. The resulting curve displays a slightly concave upwards form and trends upwards but deviation from a linear relationship is minimal and there is no global maximum or minimum. This suggests that use of the interaction term is unnecessary. Given that this multicollinearity crosses two instruments, future research should consider dropping one of these variables.

I next examined the cross product equation for *cf, ptf, and cf*ptf*. As with the investigation of *ttad* and *fteadmin*, all three terms are statistically significant. The function exhibits a slightly concave-upwards form with a downward slope and there is no global maximum or minimum. The curvilinear relationship departs only minimally from a linear relationship and changing the functional form of the model for this small adjustment is unnecessary.

The final potential candidate for multicollinearity is the relationship between *ftgrad*, *ta*, and *ftgrad*ta*. As with the relationship between *ttad* and *fteadmin*, the resulting curve displays a slightly concave upwards form and trends upwards. Deviation from a linear relationship is minimal and there is no global maximum or minimum.

Accordingly, changing the functional form of the regression model to address this mild multicollinearity is unnecessary.

ANSWERING THE RESEARCH QUESTIONS

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

The model developed for this research establishes (at least for public universities in Texas) that the Bowen hypothesis explains substantially more expenditures at universities than the Baumol hypothesis. The ratio of Bowen to Baumol expenses is highest at elite Research universities (as high as 8.4) and it is lowest at the least selective, least research intensive Master's universities (as low as 3.7). Patterns in expenditure changes differ depending on the research intensity of the institution.

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

Additional tuition did not lead to an expansion of Bowen expenditures relative to Baumol expenditures at Research institutions; indeed this ratio of Bowen to Baumol expenditures drops by -5%. This ratio also decreases at Comprehensive and Master's universities with low research intensity missions (-1% and -3%). The THECB institution types of Emerging Research and Doctoral institutions, however, display substantial increases in Bowen expenditures relative to Baumol expenditures (6% and 4%). This suggests that the lower-level research universities with aspirations to higher research intensity shift to an increasing proportion of Bowen expenditures in conditions of expanding revenue.

CONCLUSION

The results presented in this chapter demonstrate that the Martin and Hill methodology can be used to construct estimates of Baumol and Bowen expenditures for the entire range of Texas public universities. The model itself possesses a high level of statistical significance as well as substantial explanatory influence. These results broadly confirm Martin and Hill's initial work that Bowen expenditures are a larger proportion of total university expenditures than Baumol expenses. The findings also confirm my intuition that launched this project—that research intensity would lead to differential ratios of Baumol and Bowen expenditures. Unexpectedly, however, it is aspiring research universities, not top-tier institutions, that display proportional increases in their ratio of Bowen expenditures to Baumol expenditures. Finally, institutions (particularly Research universities) appear to have used additional funds from tuition deregulation to reduce existing subsidies from graduate education to the rest of the institution.

Chapter 6: Summary and Conclusions

Chapter 6 of this study reiterates the problem statement this research addresses and then answers the two research questions it asks. Following this, it reviews the results for each of the instruments in the econometric model to examine how those results might inform existing theory on higher education finance. It moves to an assessment of the significance of the findings from this research, reflections on surprising results and potential importance for practice, then addresses the limitations of the research. Finally, the chapter concludes with three concrete proposals for additional research based on the model developed for this study.

PROBLEM STATEMENT, RESEARCH QUESTIONS, AND METHODS

This chapter summarizes the conclusions of an econometric model that examines Texas public university expenditures following tuition deregulation. This model measures expenditures explained by macroeconomic factors in the general labor market (the Baumol hypothesis) and compares them to expenditures explained by unresolved agency problems, the pursuit of institutional interests, and other microeconomic factors (the Bowen hypothesis). This model answers two research questions:

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

To answer these questions, the model links expenditures at higher education institutions with instruments that measure the relative effects of the competing Baumol and Bowen hypotheses. Institutional mission can have a profound effect on spending decisions, and as a result the model controls for institutional type (and this control allows the model to answer the second of the research questions). In addition, because the analysis uses time series data, the model controls for yearly changes in the policy environment.

Regression equations solved using Ordinary Least Squares (OLS) can be shown under the Gauss-Markov Theorem to be BLUE—Best Linear Unbiased Estimator (where "best" means lowest variance of the estimate). Unfortunately, the assumptions required for OLS estimates to be BLUE are rigorous and under real-world conditions are rarely met, particularly for panel data such as that used in this research. Deviations from the Gauss-Markov assumption of constant variance can be partly addressed through changes to the residual structure that modify the standard errors reported by the procedure without changing the mean value parameter estimates that OLS provides. These adjusted standard errors are measured using either heteroscedasticity consistent (HC) or heteroscedasticity and autocorrelation consistent (HAC) estimators.

Robust regression techniques vary from OLS and OLS-derived approaches such as HC and HAC because they change the transformation used to solve the regression equation from a sum of squared values to a different function that modifies the weights given to residuals when solving the regression equation. This change results in different standard errors as well as different parameter estimates. The class of robust regressions designed to address heteroscedasticity are called "M-estimators." While M-estimators do an excellent job at controlling for heteroscedasticity, they are ineffective in controlling for data structures contaminated by influential outliers because they cannot distinguish between "good" leverage points with information from "bad" leverage points that represent contaminated data. A separate category of residual transformations attempts to distinguish these two cases, known as "MM-estimators." In this study, I report five regression results: OLS, White (HC), Newey West (HAC), Huber (M), and Yohai (MM).

The dataset used in this study generally displays fairly low levels of heteroscedasticity and some degree of autocorrelation. The results of the MM-estimator, however, show that the data exhibit substantial contamination of influential outliers that have measurable impacts on the interpretation and power of the model, most critically in overstating the explanatory value of the Compensation instrument and thus the importance of Baumol expenditures relative to Bowen expenditures. As a result, MM-estimator parameter estimates are used to generate all average values.

RESULTS

Statewide real average expenditures per FTE student at Texas public universities increased 9% from fiscal year 2003 to fiscal year 2011. Expenditure growth at Research institutions outpaced other THECB institution types (14%) and expanded their already substantial spending advantage. Fiscal years following tuition deregulation exhibit smaller standard errors when autocorrelation is accounted for, while fiscal years following tuition deregulation exhibit larger standard errors; this is evidence of a discontinuity created by the policy change. Analysis of yearly fixed effects before and after tuition deregulation suggests that the policy change led to an increase in expenditures above pre-deregulation levels on the order of $1,400 in 2011 constant dollars per FTE student at all universities (Figure 39). As expenditures per FTE student increased, FTE student enrollments also increased (by 20%). This growth was concentrated in the undergraduate population.

Constant dollar expenditures explained by Bowen expenditures declined for all university types during the study period. These declines ranged from -14% at Emerging

Research universities to -18% at Research universities (Figure 46). Baumol expenditures also declined across the sector, from -13% at Research universities to -19% at Emerging Research universities (Figure 47). These drops in Bowen and Baumol expenditures were balanced by the across-the-board increases in explained expenditures from the fiscal year fixed effect term. In addition, institutions (particularly Research universities) appear to have used additional funds from tuition deregulation to reduce pre-deregulation subsidies from graduate education to the rest of their institutions. Finding this significant reallocation of funds provides support for Bowen's hypothesis. These are savings that could have been passed to students or returned to the state rather than distributed within the university. Instead, additional revenue was used to increase the prestige of universities engaging in research by improving the quality of graduate students by increasing the subsidy granted these students through graduate and teaching assistantships.

Question 1: To what degree do the competing Baumol and Bowen hypotheses explain expenditure changes at public four-year institutions of higher education?

The model developed for this research establishes (at least for public universities in Texas) that the Bowen hypothesis explains substantially more expenditures at universities than the Baumol hypothesis. The ratio of Bowen to Baumol expenses is highest at elite Research universities (as high as 8.4) and it is lowest at the least selective, least research intensive Master's universities (as low as 3.7). Patterns in expenditure change differ depending on the research intensity of the institution.

Question 2: Do public, four-year institutions of higher education with strongly defined research missions exhibit different choices in expending these new funds?

Additional tuition did not lead to an expansion of Bowen expenditures relative to Baumol expenditures at Research institutions; indeed the ratio of Bowen to Baumol expenditures drops by -5%. This ratio also decreases at Comprehensive and Master's universities with low research intensity missions (-1% and -3%). The THECB institution types of Emerging Research and Doctoral institutions, however, display substantial increases in the proportion of Bowen expenditures relative to Baumol expenditures (6% and 4%). This suggests that the lower-level research universities with aspirations to higher research intensity shift an increasing proportion of spending toward Bowen expenditures in conditions of expanding revenue.

RELATIONSHIP TO LITERATURE

As I wrote in the beginning of this study, given that the Baumol and Bowen hypotheses both have strong theoretical bases, this research was never intended to "prove" one or the other correct. Rather, my goal was to understand more fully the relative importance of the two hypotheses. I find that the Bowen hypothesis explains substantially more expenditure behavior than the Baumol hypothesis for Texas public universities. In other words, these expenditures are driven more by firm-level microeconomic explanations than economy-level macroeconomic explanations. Within the general calculation of Baumol and Bowen costs, the results from six discrete instruments provide insight into why this relationship exists.

Scale Changes.

The cost function of universities varies based on their mix of graduate and undergraduate students. One question concerning this relationship is whether a population of graduate students provides institutions the ability to cross-subsidize between groups of students or whether graduate education is itself a cost-driver. The results of this study demonstrate that cross-subsidization occurs. The Scale Change instrument displays substantial variation by research intensity across the sector, with Emerging Research and Research universities displaying a large amount of potential cross-subsidy from graduate education to elsewhere in the university.

The estimated amount of this subsidy drops rapidly during the study period at Research universities, from -$6,943 to -$4,850 (-30%) and -$3,194 to -$2,746 (-14%) at Emerging Research universities. This drop results from increasing expenditures on teaching and graduate assistants (Figure 40). Reducing the subsidy from graduate education to the rest of the university is likely an effort to improve the prestige of these universities by improving their input of graduate student quality and thus research and other forms of scholarly output from future students.

Cost Savings.

The results of the Cost Savings instrument suggest that, while higher ratios of part-time faculty per FTE student do decrease total expenditures as expected, contract faculty are *more* expensive than tenure track faculty on a per FTE student basis. This is a surprising and interesting finding; it is possible that the substitution of contract faculty for tenure-track faculty results not in short term savings costs but rather in avoiding long-term financial constraints (and that universities pay a contract faculty a premium for this flexibility).

From 2003 to 2011, universities reduced expenditures as measured by the Cost Savings instrument (Figure 41). This expenditure drop was particularly pronounced at Research universities ($4,821 to $2,636, -45%) and Doctoral universities ($5,154 to $2,383, -54%). Smaller drops occurred at Emerging Research (-25%), Comprehensive

(-37%), and Master's universities (-25%). These drops are the result of sharp reductions in the ratio of full-time, non-professional employees (Figure 23).

Revenue.

The proportion of expenditures explained by this instrument declined for all institution types, ranging from a drop of -7% at Research universities to -14% at Comprehensive universities. This decline reflects the greater rise in other revenue than total revenue (Figure 35 and Figure 36) and potentially indicates that these new "other" revenue sources are less stable than core revenue.

Productivity.

Expenditures explained by the productivity instrument declined following tuition deregulation, particularly at Research universities (-30%) while Emerging Research universities declined -17%, Doctoral universities declined -6%, and Comprehensive and Master's universities declined -2%. These drops are correlated exactly with research intensity as measured by THECB institution type (Figure 44) and suggest that the role of full-time administrators per FTE student in explaining spending declined following tuition deregulation. This finding indicates that "administrative bloat" following tuition deregulation is not a driver of increased expenditures. Of particular note is that Research universities increased their ratio of tenure-track faculty to administrators following tuition deregulation by 6% (Figure 21).

Compensation.

From 2003 to 2011, all institutions exhibited real drops in expenditures explained by the Compensation instrument. These drops were of similar scale, ranging from -13% at Research universities to -19% at Emerging Research universities (Figure 42). Martin and Hill's research suggests that 51% of salaries and 52% of benefits can be associated with the Baumol hypothesis. This study demonstrates that, at least for Texas public universities in this time period, the proportion of Compensation expenditures the Baumol hypothesis explains is substantially higher than Martin and Hill's estimate—61% of salaries and 70% of benefits. Declines in the proportion of expenditures explained by this instrument directly contradict the Baumol hypothesis that labor costs will increase faster than the general price level. This finding is corroborated by the variables that measure salaries and benefits. Figure 11 and Figure 13 demonstrate that salaries rose at the same level as CPI between 2003 and 2011 while benefits increased by only 2% in real terms. Compensation also varies little by THECB institution type, suggesting that all these universities exist in a similar labor market and pay roughly the same market-clearing wages (with some divergence between lower compensation at Emerging Research universities and the rest of the sector).

Governance.

The low and declining level of expenditures explained by this instrument, combined with the failure to find evidence of a quadratic function with a global minimum for the tenure-track to administrator independent variable, means this study does not support Martin and Hill's contention that there is a "Golden Mean" balancing the tenure-track faculty and professional administration (Figure 45). This removes the single theoretical internal structure they propose with the potential to restrain expenditure growth and ameliorate potential agency abuse from both parties.

SIGNIFICANCE

The implications of this research are both important and positive. Imagine, for example, if the Baumol hypothesis explained a greater proportion of university expenditures than the Bowen hypothesis. Universities have limited ability to shape and control the broad labor market factors that the Baumol hypothesis invokes to explain expenditure patterns. Under this hypothesis, the very nature of the labor-intensive production function at universities would render the expense of providing a university education beyond the ability of families and society to afford. The consequences of this increased expense would be an inevitable, revolutionary change in the provision of post-secondary education. Students of modest means, even solidly middle-class students, would find themselves locked out of a "traditional" higher education experience. That experience, in turn would become both a luxury good and a class marker to an even greater extent than it is currently. Students unable to afford this luxury good would be forced to settle for second-best options such as impersonal, massive online courses, experiential credit, and a generally less personalized higher education experience. This bifurcation of post-secondary education would have profound societal consequences.

Finding that the Bowen hypothesis possesses substantially more explanatory power than the Baumol hypothesis provides at some hope that incremental changes in existing structures can address increases in student expenditures. The problem is that universities lack structures to force choices between these competing good ideas and so enforce market discipline. In a way, this research provides a case study of what happens when an effective structure imposing this discipline—Texas' statutory restrictions on tuition increases—is removed. One concrete way to address increasing expenditures per FTE student in Texas, for example, would be to reverse tuition deregulation and once again require public universities to make the case to the elected leadership of the state for tuition increases.

Renewing this supplicant relationship also has the potential to help bridge the other challenge raised by the Bowen hypothesis—addressing the principal-agent problems that allow the misallocation of resources within non-profit firms. A naïve solution to this problem would focus on removing the "non-profit" element of the relationship—in other words, privatization and the introduction of the profit motive to the firm. I think this would be a mistake. Public universities are *public*. We have a principal-agent problem in non-profit, public universities not because they are non-profit but because there are barriers between the public and their institutions. Review and oversight of tuition and fees by elected officials goes some small way to addressing this but as long as this authority is delegated the ability of civil society to exert oversight on public university expenditures will be limited.

The state could choose to strengthen existing oversight structures (such as THECB and the various boards of regents and system offices) however these other bureaucracies are not the principal in the principal-agent problem either and in any event are subject to regulatory capture. Perhaps some part of the answer to solving the principal-agent problem is for the public—the true principals—to be involved more directly into the operation of public universities. Imagine, for example, a committee of alumna/i, local civic leaders, students, and parents being brought explicitly into the budget formulation process at institutions in a manner similar to a local school board. These citizens would be able to both weigh in as independent observers on budget decisions and to be more broadly informed about the rationale behind those decisions.

UNEXPECTED AND SURPRISING FINDINGS

My expectation prior to beginning this research was that Bowen expenditures would be correlated with research intensity, which this study demonstrates is indeed the case. I also, however, expected that following tuition deregulation the *rate of growth* of Bowen expenditures at Research universities would increase. In other words, freed from the strictures of tuition control, these institutions would expand their spending on internal, non-labor-market dictated activities. In absolute terms, this did occur—but in relative terms the proportionally greater increase in Baumol expenditures was a surprise. I also did not expect to see this hypothesized relationship appear not in the Research universities but in the aspirants to top-tier research activity—the Emerging Research universities.

RECOMMENDATIONS FOR PRACTICE

There are practitioners in two realms who could find the results of this study enlightening. For those making budget decisions at universities, the most profound finding is the massive gap between those institutions at the top of the research-intensity continuum and other universities. The difference in Bowen expenditures between the Research and Emerging Research universities in 2011, for example, was $14,089 per FTE student. This chasm of money pays for a large amount of activities (e.g., institutional support, laboratory facilities) that are required to compete and engage in research at the highest level and amounts to a qualitative difference between true research universities and all other institutions. In the absence of significant additional funding, leaders at institutions not in the top research tier would do well to sharply restrict expenditures that are mere halting efforts in the direction of expanded research—or at least focus them quite deliberately.

The other practitioners who might gain some insight from this study are those public officials charged with the oversight and control of public universities. The importance that the Bowen revenue theory of costs clearly has in explaining university expenditures strongly implies that no set of policies allowing universities to raise these expenditures will ever satiate the desire for even more expenditures. In addition, the failure of the only posited theoretical, internal mechanism to restrict expenditures—a

"Golden Mean" of faculty to administrators that keeps the worst tendencies of both in balance—strongly suggests that meaningful control of increases in Bowen expenditures must arise from some external force.

LIMITATIONS

The fundamental limitation of this study is that it examines public universities. Private universities operate in a different environment than the public sector. Consider a small undergraduate liberal arts college such as Sweet Briar College compared to Harvard. Now consider Sul Ross State (a small school in Alpine, Texas) and UT Austin. Small private schools close if they do not attract sufficient students while prestigious, well-endowed universities can essentially run without any tuition revenue and use student fees mainly as a signal of quality and to manage already overwhelming applicant pools. Small public schools, on the other hand, generally remain open with state support even with large declines in enrollment while elite public schools, even with significant endowments, also have large student bodies and require significant tuition revenues to maintain their status. Given that there are substantial differences in Bowen and Baumol expenditures by THECB institution type in Texas, an even broader divergence in the national, private university sector should be expected.

IMPLICATIONS

The similar level of Baumol expenditures across THECB institutional types and the largely similar change in these expenditures over the course of this study suggests that public higher education institutions exist in a broad, national labor market for academic talent. Private institutions, particularly elite private institutions, clearly play a role in shaping this market. Highly-sought potential hires for tenure-track positions, for example, choose between competing offers from public and private institutions. Because this research was conducted on one part of the academic labor market it does not provide insights on how the balancing of Bowen and Baumol expenditures at market-leading elite private universities might have an impact at public universities.

FUTURE RESEARCH

There are at least three areas of future research that could expand the understanding of university expenditures provided by this econometric model. First, while Texas public universities have functioned in a period of flat-to-moderate increases in overall state support, other state policy environments have been different. A state with a relatively large number of public institutions that experienced absolute budgetary reductions (and perhaps lower growth in real per FTE student expenditures) would provide an interesting counterpoint to this study, as it would examine expenditure decisions made to allocate cuts, rather than to allocate additional funds. In particular, an examination of cross-subsidization between graduate education and the rest of the institution in that policy environment would be useful. Such a study could be performed in the same 2003 to 2011 period as this research using the IPEDS database.

A second area of future research that could prove fruitful would be Texas-specific and would modify this econometric model to use Martin and Hill's measurement of academic costs, rather than total costs. Such a revised model would institute controls for athletics and other activities associated with auxiliary and non-academic functions of universities. Unfortunately, the IPEDS system does not provide sufficient discrete employment data to isolate employment associated with academics from other university employment. It is possible a state-specific database could provide this information and substitute for IPEDS employment data. One particularly interesting question this second research project could address is the level of cross-subsidy between core academic and auxiliary functions at different university types.

A final avenue of potential research involves the production function of universities. This study treats universities as single product firms producing students and controls for the secondary research output of multi-product firms by grouping universities into THECB institution types. Assuming a reasonable metric for research output could be developed, the model could be modified to account for a more granular measure of the multi-product nature of universities. In the other direction, the model developed for this study could be applied to the true single-product firms in higher education: community colleges with controls for research intensity replaced with controls for community characteristics.

CONCLUSION

This study has presented both a case-study of tuition deregulation in public universities and an econometric model examining the reaction of these institutions in allocating expenditures following tuition deregulation. The findings of this research are quite clear—that public universities possess considerable potential autonomy in making decisions on expenditures and are not merely blown hither and fro by the forces of the larger labor market. The challenge we face is how to create structures that ensure the spending choices made by leaders of these institutions do not continue to generate a spiraling and unsustainable rate of expenditure growth. Hopefully this research demonstrates that there is a potential alternative to a dystopian future of post-secondary education that would, due to radically increased expenditures, exclude all but the most fortunate from enjoying the benefits—both personal and economic—of higher education.

Appendix

Texas Public Universities by THECB Institution Type (Fiscal Year 2011)

Research Universities

- Texas A&M University
- The University of Texas at Austin

Emerging Research Universities

- Texas State University[11]
- Texas Tech University
- The University of Texas at Arlington
- The University of Texas at Dallas
- The University of Texas at El Paso
- The University of Texas at San Antonio
- University of Houston
- University of North Texas

Doctoral Universities

- Sam Houston State University[12]
- Texas A&M University – Commerce
- Texas A&M University – Corpus Christi
- Texas A&M University – Kingsville
- Texas Southern University
- Texas Woman's University
- The University of Texas – Pan American

[11] Texas State University was moved from Doctoral to Emerging Research in January 2012. It is placed in Emerging Research for all years.
[12] Sam Houston State University is not included in this study due to missing data in fiscal year 2002.

Comprehensive Universities

- Lamar University-Beaumont
- Prairie View A&M University
- Stephen F. Austin University
- Texas A&M International University
- West Texas A&M University

Master's Universities

- Angelo State University
- Midwestern State University
- Sul Ross State University
- Sul Ross University – Rio Grande[13]
- Texas A&M University-Galveston
- Texas A&M University-Texarkana
- The University of Texas at Brownsville[14]
- The University of Texas at Tyler
- The University of Texas of the Permian Basin
- University of Houston- Clear Lake
- University of Houston- Downtown
- University of Houston- Victoria

[13] Sul Ross University – Rio Grande is included in Sul Ross University data in IPEDS.
[14] The University of Texas at Brownsville is excluded from this analysis due to its unique taxation and facility sharing arrangements with the local community college district (Texas Southmost College).

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Vita

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This dissertation was typed by the author.